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Erasmus Darwin

BY DESMOND KING-HELE

This latest study of Erasmus Darwin (1731–1802) brings from semi-obscurity a man who was anything but obscure in his own day. Famous as the finest doctor of his time, a best-selling poet, and a prolific inventor, he also propounded many scientific theories, most notably that of evolution. Concerning this, C. D. Darlington in his biography of Charles Darwin wrote: "A convincing argument appeared for the first time . . . in the work of Darwin's grandfather at the end of the eighteenth century."

A prophet even with honor in his own country, he was while he lived compared to Da Vinci and the contemporary Goethe. Mr. King-Hele writes vividly, reviewing Dr. Darwin's achievements and assessing his significance for our times. He also examines his personality, his chief literary works, and his influence on the great Romantic poets and the first and most famous piece of science fiction, Mary Shelley's *Frankenstein.*

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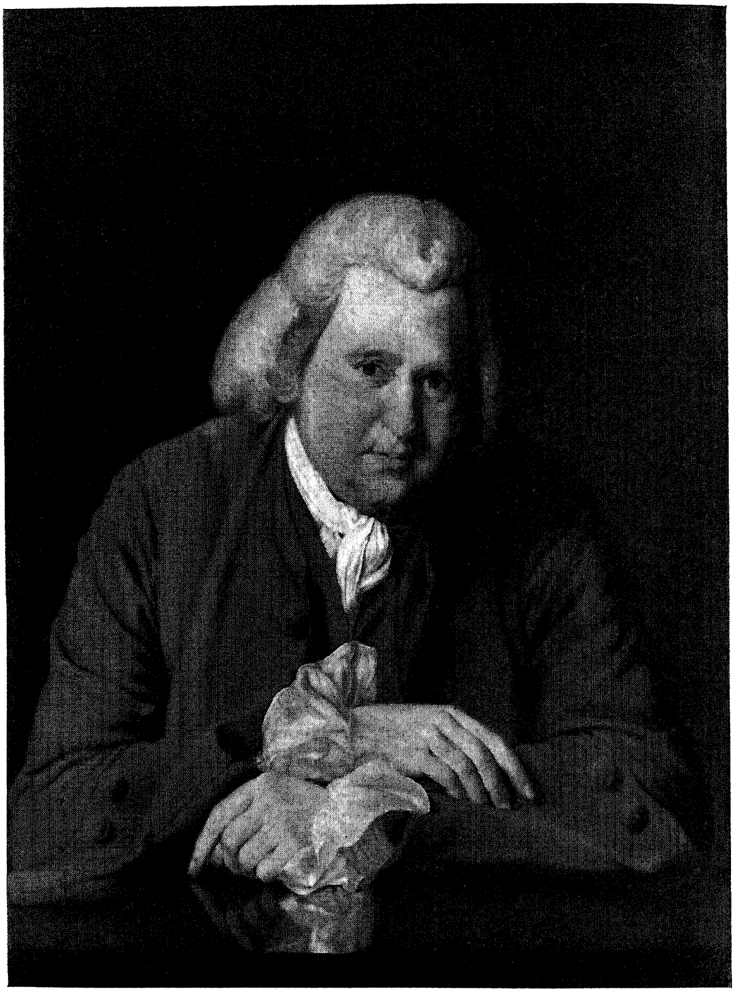
ERASMUS DARWIN

MAR 1964



ERASMUS DARWIN

From a portrait by Joseph Wright of Derby
in the National Portrait Gallery, London

ERASMUS DARWIN

DESMOND KING-HELE

CHARLES SCRIBNER'S SONS
New York

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PREFACE

ERASMUS DARWIN was famous in his own lifetime as a best-selling poet, the finest doctor of his day, a prolific inventor, a witty talker and a propounder of many scientific theories, including evolution. In the 160 years since his death there have been three biographies, and one or two monographs on particular aspects of his thought; but there has been no general account of the work which earned him his fame. In this book, therefore, my chief aim has been to try to review all possible facets of his many-sided achievement, and to assess their significance for our times. The book is intended to be read without the numbered notes, most of which merely give the source of quotations or references for further reading.

I am most grateful to those who have advised me: first and foremost among these is my wife Marie, whose perceptive criticisms of the successive drafts of this book have helped so greatly to improve it. I thank Lady Barlow for valuable comments on Chapter V, and Mr. W. R. B. Hynd and Professor Irwin Primer for useful information on points of detail. I am also much indebted to Mr. Richard Parker and the staff of the Farnham Branch of the Surrey County Library for their unfailing help in obtaining for me all the books I needed, including many obscure eighteenth-century works. For permission to reprint part of an article which appeared in Bulletin XIII of the Keats–Shelley Memorial Association, I thank the editor, Miss Dorothy Hewlett. Finally, I am grateful to Mr. S. Robinson, custodian of

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Down House, Kent, for his courtesy in enabling me to study Erasmus Darwin's manuscript Commonplace Book, which is kept there, and to the Royal College of Surgeons of England for permission to quote extracts from the Commonplace Book.

D. K.

FARNHAM,
November 1962

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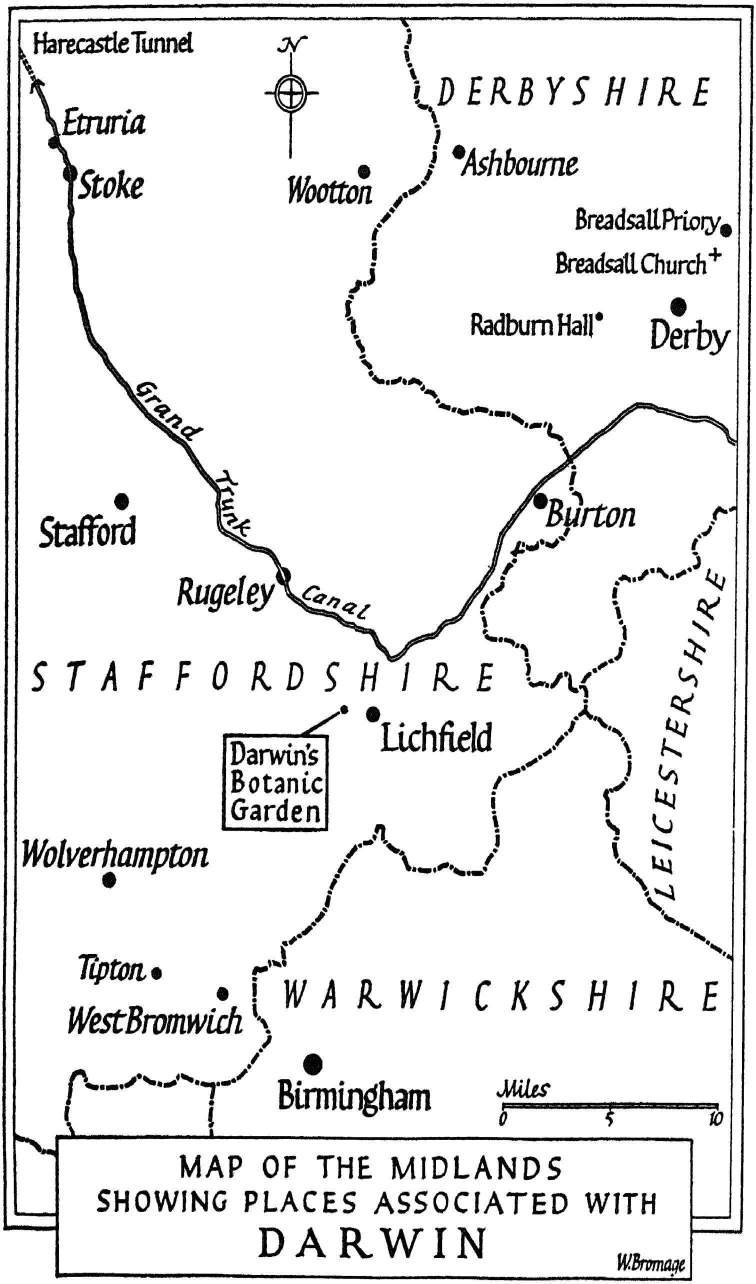
Map of the Midlands, showing places associated with Darwin *Facing page* 1



MAP OF THE MIDLANDS SHOWING PLACES ASSOCIATED WITH

DARWIN

I

INTRODUCTION

> that eager mind, whom fools deride
> For laced and periwigged verses on his flowers;
> Forgetting how he strode before his age,
> And how his grandson caught from his right hand
> A fire that lit the world.
>
> ALFRED NOYES, *The Torch-Bearers*

ERASMUS DARWIN, who lived from 1731 till 1802, took all knowledge as his province, yet passed most of his life within the narrow compass of a Midland doctor's daily rounds, first at Lichfield and later at Derby. A keen observer of both Man and Nature, he delighted in devising scientific theories to explain everything he saw. Specialization was foreign to him; he was the general practitioner *par excellence*, famous in his own day as a doctor, a scientist, a poet, an inventor and a talker. He had a rare universality of mind, and an easy grasp of physical and biological science.

Darwin could only exercise these talents, however, when free of his medical duties: he devoted most of his time and energy to his patients, serving them so well, and achieving so many remarkable cures when other doctors had abandoned hope, that he was recognized as the best physician of his time. The countless interviews which make up the general practitioner's everyday work are rarely chronicled, and even if they were it would often be difficult to say whether the doctor's skill or the patient's constitution deserved the credit. The artist, the poet and the research scientist record their work for the benefit or scorn of posterity; but the doctor — like the schoolteacher, the barrister and the mother of a family — responds to transient stimuli, and his skill (or perhaps genius), even if recognized, usually goes unrecorded. His masterpieces — patients who recover — cannot defy time, like the sculptor's stone, the poet's printed work or the scientific law. Lasting fame comes rather to the doctor who specializes and makes a significant discovery or writes a classic book on his speciality. Darwin's reputation has suffered particularly from his refusal to specialize, because even the most enlightened eighteenth-century physician seems sadly ignorant to-day, at least in face of germ-born disease. Darwin succeeded amazingly well with primitive equipment, yet his successes now excite more curiosity than respect. So his medical practice, though it accounted for perhaps two-thirds of his waking life, occupies a much smaller proportion of this book.

Of the remaining fraction of his time, much was taken up by an active domestic and social life: he married twice and had fourteen children; and he founded various scientific societies including the famous Lunar Society. Among his close friends were many of the Midland technologists who were bringing about the Industrial Revolution: Josiah Wedgwood the potter; James Watt the engineer; James Keir the chemist; Matthew Boulton the industrialist. His varied friends outside this group included that eccentric inventor R. L. Edgeworth, the father of Maria and twenty-one other children; Rousseau, the father of Romanticism; and Anna Seward, the 'Swan of Lichfield'. Darwin's fertile mind, ever at the service of his friends, generated a seething stream of ideas, inventions and theories. He had little time to follow them up and has had no credit for many ideas which others carried to fruition. He initiated dozens of inventions but developed only a few to the engineered product, and he speculated boldly in all realms of science and sociology.

In this book his life story is told in Chapter III, after a brief review of the eighteenth-century medical background in Chapter II.

Chapter IV discusses his ideas on animal and vegetable life, as revealed in his massive books, *Zoonomia* (1794) and *Phytologia* (1800). *Zoonomia* is far more than a medical textbook: it is both a philosophy of life and a mine of speculations on man. Darwin's approach was often remarkably modern: in treating mental illness and in emphasizing that the patient is a complete individual, not a mere body, he was far ahead of his time and, in a few respects, of ours too. *Phytologia* put gardening and agriculture on a sound scientific basis, with its long discourses on plant nutrition, photosynthesis, fertilizers and manures.

Chapter V deals with one outstanding topic from *Zoonomia*, Darwin's theory of evolution, which is his chief claim to fame in the history of science. My scrutiny of the evidence drives me to conclude that the Darwinian theory of evolution is very much a family affair, in which the shares of Erasmus and his grandson Charles are more nearly connected, and more nearly equal, than is usually supposed. As Darlington has pointed out, Erasmus's work has been effectively suppressed, largely because of some ambiguous remarks by his grandson, which have 'now deceived three generations'.[1] Samuel Butler's attempt to end this suppression did more harm than good, because he foisted his own erroneous views on Erasmus. Consequently Erasmus is still greatly underrated and misrepresented. For example, in a recent book on evolution, Professor C. H. Waddington, one of the leading authorities on the subject, dismissed Erasmus Darwin by referring to *Zoonomia* as 'a long and unfortunately remarkably boring poem':[2] in fact *Zoonomia* is in prose, and Erasmus's theory of evolution was in several ways nearer than his grandson's to the modern version. Its publication provoked strong condemnation from the religious, and Erasmus, unlike his grandson, was overwhelmed by this opposition, because he had not enough detailed evidence, and because in the 1790s England was in nervous tension after the French Revolution and extremely suspicious of any theory which subverted existing ideas.

Chapters VI and VII discuss Darwin's long poems, *The Botanic Garden* and the posthumously published *Temple of Nature*, which together provided a conspectus of existing scientific knowledge, seen in the light of his evolutionary philosophy of life and presented in skilful rhyming couplets.

The Botanic Garden (1789–91) won high praise from almost every quarter and became a best-seller. *The Temple of Nature* (1803) was not so well received because his evolutionary ideas were by then regarded as subversive of religion. Though Darwin's concept of poetry is now *démodé*, he has few equals in expository verse and the art of sugaring the factual pill: no man 'had a more imperial command of words'.[3] These poems seem overdue for reappraisal, especially since, hidden away among their long essay-notes, we find various scientific discoveries usually credited to later investigators.

Darwin was a great seminal influence in literature as well as in science, and Chapter VIII deals with his reputation as a poet and his effect on the Romantic poets, particularly Wordsworth, Coleridge and Shelley.

Chapter IX is devoted to his inventions and researches. The inventions range from the practical and engineered, like his speaking-machine, to the speculative and correct, *e.g.* the hydrogen–oxygen rocket motor, and the merely curious, such as telescopic candlesticks. The researches touch on subjects ranging from artesian wells to eyesight.

Darwin was most original in his ideas, and covered the widest possible area, from mechanics to philosophy, from poetry to medicine. He propounded many theories which, though rejected at the time, later proved to be true. One of the sincerest tributes to his powers comes from Coleridge, who detested his 'absurd' evolutionary theories, deplored his atheistic tendencies and was 'nauseated' by his poetic style. Nevertheless, on visiting Darwin in 1796, Coleridge wrote: 'Derby is full of curiosities, the cotton, the silk mills, Wright, the painter, and Dr. Darwin, the everything, except the Christian! Dr. Darwin possesses, perhaps, a greater range of knowledge than any other man in Europe, and is the most inventive of philosophical men. He thinks in a *new* train on all subjects except religion.'[4] And a year later he gave it as his opinion that Darwin was 'the first *literary* character in Europe, and the most original-minded Man'.[5]

NOTES TO I: INTRODUCTION

(In these notes the title of a book may be shortened and its date omitted if it appears in the book list on pages 173-5, where full details are given.)

1. C. D. Darlington, *Darwin's Place in History*, p. 63.

2. *A Century of Darwin* (ed. S. A. Barnett) (Heinemann, 1958), p. 1. Reprinted unchanged in Mercury Books, 1962.

3. *Monthly Magazine*, vol. xiii, p. 462 (1802).

4. Coleridge, *Letters*, I. 177.

5. Coleridge, *Letters*, I. 305.

II

EIGHTEENTH-CENTURY MEDICINE

> They answered, as they took their Fees,
> 'There is no Cure for this Disease.'
> HILAIRE BELLOC, *Cautionary Tales*

THE medical science available to Darwin was primitive by modern standards: in some branches of medicine the methods of the ancient Greeks had scarcely been improved upon. Since the germ theory of disease was unknown, surgery was hazardous and childbirth chancy. The instruments for detecting disease were ineffectual, and so were the antidotes against it. 'Slow ahead' at best and 'full astern' at worst had been the rate of advance in medicine since antiquity, and there had been few of those fundamental discoveries which stimulate progress by their wide implications.

Though the art of medicine must have been practised from the earliest times, and flourished in ancient China and Egypt, its first recognized master is Hippocrates in the fifth century B.C. Hippocrates, who is still regarded as the greatest of physicians, has permanently influenced the medical profession, both in technique and in conduct. In technique, the many volumes of the *Hippocratic Collection*, with their detailed accounts of operations, case-histories and surgical methods, provide an admirable model. In conduct, Hippocrates himself seems to have been the ideal of the good physician: calm, kindly, prompt, observant, cautious and incorruptible; certainly this was the spirit inculcated in the writings, and it survives to-day in the Hippocratic oath.

Also very important in the history of medicine is Aristotle (384–322 B.C.), a fine biologist especially skilled in comparative anatomy. But he had many wrong ideas which were perpetuated because of the high esteem he later enjoyed. For example, he believed that in generation the male contributes nothing material, but only the essence of life; this idea, which was naturally attractive to Christians because they were required to believe in a virgin birth, remained common until the nineteenth century, although Erasmus Darwin necessarily rejected it in propounding his theory of evolution.

In Roman times medical science advanced little, though public health improved because of technological innovations, such as hospitals and the admirable water supplies in Roman cities. The medical treatises of Galen (A.D. 130–200) had an immense influence, however, because after his death medicine, like most of the sciences, came nearly to a full stop in Europe for over a thousand years. This long 'dark night of the body' coincided with the rise of Christianity — and not just by chance. For it was thought that disease, being sent by God, could best be cured by prayers and fasts. Also, although Christians were encouraged to tend the sick and succour the needy, preserving the body in this world remained subordinate to preparing it for the next. Even washing was frowned on, and when the sight of a naked body in a bath was deemed displeasing to God, dissection was almost unthinkable.

Though these years were barren in Europe, medicine continued to thrive among the Arabs. The Persian Rhazes (865–932) ranks among the greatest physicians, and so does Avicenna (980–1037), whose *Canon of Medicine* had a wide influence.

The revival of medicine in Europe, like that of science and art, began in Italy, slowly at first, from the fourteenth century onwards. Leonardo's remarkable work remained almost unknown until much later, and the modern era can be said to start in the same year as Copernicus's revolutionary book on astronomy, 1543, when the classic textbook on *The Fabric of the Human Body* was published by Andreas Vesalius

(1514–64), a Belgian who was professor at Padua. This book, the product of close and accurate observation and dissection, at once superseded the antiquated works of Galen, and set the wheels of progress turning. They turned slowly, however, and from then until 1700 there were few major advances, of which we need only mention three. First and foremost is William Harvey's great discovery of blood circulation, published in 1628, which transformed the theory and practice of medicine (though the fact that blood circulates was apparently known to the Chinese Emperor Huang Ti in 2600 B.C.[1]). Second is the invention of the microscope, and its use by many skilful observers. Leeuwenhoek (1632–1723), pre-eminent among these observers, first glimpsed microbes in 1683, but no one saw them again until after 1800.[2] For microscopy was neglected in the eighteenth century and recognition of the rôle of microbes in disease was thereby delayed, although Girolamo Fracastoro of Verona had expounded the germ theory in his book *De Contagione* (1546) and specified the three modes of infection: by direct contact; indirectly on clothes, etc.; and through airborne germs.[3] Third, there is the work of Thomas Sydenham (1624–1689), sometimes called the English Hippocrates, who investigated how disease arose and how it spread, and came near to rediscovering the germ theory. He also popularized the use of quinine, or 'Jesuit's bark', as it was known, because it came from the rind of the South American Cinchona tree, and was brought to Europe by Jesuits.

The eighteenth century saw no startling discoveries, nothing worthy to set beside those of Harvey in the seventeenth or Pasteur in the nineteenth. Techniques were slowly improved, however, and by the end of the century people in England were enjoying slightly better health and longer lives, despite the Industrial Revolution. Probably the most influential figure of the century was Hermann Boerhaave (1668–1738), professor at Leyden, a widely accomplished man, who emphasized that patients should be studied as individuals. This rule he applied to both the quick and the dead, for he believed in checking diagnosis by a postmortem. Boerhaave made Leyden the world's leading medical centre, and most of the teachers at the Edinburgh school of medicine had been his pupils. The Edinburgh school, founded in 1726, was flourishing and famous by 1750, and attracted students from far and wide, among them Erasmus Darwin.

The century's leading physiologist was a Swiss pupil of Boerhaave, Albrecht von Haller (1708–77), who excelled in other subjects too, from poetry to anatomy. In his textbook on physiology (1759–66) he described researches into the mechanics of breathing, the formation of bone and the growth of the embryo. He also showed how the nervous system functions, noting that muscle fibre tends to contract strongly, even under a weak stimulus. Haller distinguished the inherent muscular force from the nerve-impulse which reaches it from outside, and was able to prove that the nerves come together in the brain.

Haller had no idea that the nerve-impulses were electrical, however: this discovery did not come until after 1850, though we can now see how it was foreshadowed in the 1790s by Galvani, with his famous experiments on the twitching of frogs' legs when touched by different metals, and by Volta, who showed that muscles could be continually stimulated by electrical impulses. Even before these two Italians began their researches, however, Darwin, seeing how paralytic limbs were stimulated by electric shocks, had come to the conclusion that nerve-impulses were electrical.[4]

The studies of blood circulation begun by Harvey were extended, particularly by Stephen Hales (1677–1761), an English country parson who, like Darwin, was a keen advocate of temperance. Hales measured blood pressure and circulation rates and showed how capillary vessels contract and dilate. Not until much later, however, was blood pressure used to help in diagnosing disease: Darwin never mentions this technique in his *Zoonomia*, fond though he was of bleeding as a treatment.

Blood-study also profited, indirectly, from discoveries in chemistry. By 1750 nearly all scientists had come to accept the phlogiston theory of air, which held that a burning substance gives off an imaginary effluvium called 'phlogiston'. The true mechanism — the burning substance combining with oxygen — was in effect demonstrated by Joseph Priestley in some classic experiments during the 1770s, when he prepared oxygen from mercuric oxide, and proved that plants gave off a similar breathable gas, capable of changing blood from venous to arterial form.[5] But Priestley was so bemused by the phlogiston theory that he failed to bring out the implications of his discoveries: he called oxygen 'dephlogisticated air'. Consequently, more of the credit for inaugurating modern chemistry goes to Lavoisier, who extended Priestley's work and interpreted the results correctly in his famous textbook of 1789. Darwin, a friend of Priestley, was right up to date with these researches, but, unlike Priestley, was not misled by the phlogiston theory: he fully appreciated oxygen's vital rôle in the blood circulation.

The greatest surgeon of the century, John Hunter (1728–1793), though he did fine work in pioneering new techniques and amassing thousands of specimens for his famous museum, failed to rediscover the germ theory of disease. And, far more surprising, neither he nor anyone else recognized the worth of anaesthetics, which were known to surgeons as diverse as the Chinese Hua To in the second century A.D. and Hugh of Lucca in the thirteenth [6] (who used opium, mandragora and henbane mixed with the juice of lettuce, ivy, mulberry, sorrel and hemlock). Surgery remained a painful and risky business until after 1840, when anaesthetics and then antiseptics brought insensible safety. The ignorance of hygiene was bad enough in surgery, but even worse perhaps in childbirth. Births were supervised by midwives who were too often ignorant and dirty, and carried the germs of 'puerperal fever' from one patient to the next. The brutal forceps often used did not improve the chances of survival for either mother or child, when any wound was so liable to suppurate.

The failure to revive the germ theory of disease continually blocked progress. It also illustrates well the truism that we fail to see the obvious if the obvious does not fit in with our prejudices. For, although it would be unreasonable to expect anyone to have known of Fracastoro's treatise, there were many pointers towards the germ theory. For centuries lepers had been kept isolated, and quarantine laws had existed against contagious diseases. Then, in 1721, Lady Mary Wortley Montagu introduced the Turkish practice of smallpox inoculation, whereby live virus from someone who had the disease mildly was injected into others: their subsequent attack, usually mild, protected against further infection. Jenner's discovery that it was better to use the cowpox virus did not come until the very end of the century, when Darwin's medical career was almost over.

Since the germ theory was unknown, hygiene was improved only by chance, either for aesthetic reasons or by intuition. Many of England's open sewers were covered during the century, because they were deemed offensive; Army camps were relatively hygienic, thanks to regulations imposed by Sir John Pringle; many hospitals were built; and prisons were made less insanitary after the efforts of John Howard. So it is not too surprising that, on the whole, English people were slightly healthier in 1800 than in 1700.

A few diseases did lose some of their terror. The mercury treatment for syphilis became standardized and was scarcely improved till after 1900. James Lind conquered scurvy by proving that an abundance of fruit juices could ward off the disease, and so saved the lives of thousands of seamen in the second half of the century. Digestion became less of a mystery, thanks largely to Réaumur (1683–1757) and Spallanzani (1729–99), who established that the gastric juices can dissolve food and that we do not digest solely by churning action, as had previously been supposed. The chemical make-up of the digestive juices remained unknown until after 1800, however.

Doctors did little during the century to improve their inefficient clinical instruments. Their thermometers were useless for taking a patient's temperature: the clinical thermometer was not widely used until long after 1800.

They knew how to measure blood pressure, but never did so. Microscopic analysis was almost unknown. Chest-tapping, begun in the 1760s, was very slow to take on, and the stethoscope was not invented until after 1800. So the eighteenth-century physicians lacked almost all the common tools of to-day's general practitioners, and in diagnosing disease their main hope, apart from obvious physical symptoms, was the pulse. Even here, however, they resisted improvements and rarely used the one-minute pulse-watch developed early in the century by that other eminent physician of Lichfield, Sir John Floyer. Many diagnoses depended on deciding whether the pulse was 'strong' or 'weak': since pulse-strength varies from patient to patient, the decision was fraught with error, and Darwin's elaborate instructions on the subject in *Zoonomia* are far from convincing.

Correct diagnosis was perhaps not of prime importance, however, when the treatment for most diseases was so similar, consisting mainly of purgatives, emetics, bleeding and a few favoured herbs, either all at once or singly.

Being mentally ill was even worse than being physically ill. Lunatics were usually chained up and brutally treated, in the hope that the devils which possessed them might become uncomfortable and depart. A few doctors, however, of whom Darwin stands as the leader, were sympathetic in their treatment, and the first humane lunatic asylum was established at York in 1792 by the Quaker William Tuke. But these milder measures did not become common in England until well into the nineteenth century.

This, then, is the background, a rather depressing one of ignorance, error and squalor, against which Darwin made his daily rounds as a doctor.

NOTES TO II: EIGHTEENTH-CENTURY MEDICINE

1. See D. Guthrie, *A History of Medicine*, p. 35.
2. See C. Singer, *History of Biology*, p. 169.
3. See K. Walker, *The Story of Medicine*, pp. 216-17.
4. See *Economy of Vegetation*, I. 367, note.
5. See T. E. Thorpe, *Joseph Priestley*. pp. 167-223.
6. See W. J. Bishop, *The Early History of Surgery*, pp. 42-3, 60.

III

LIFE STORY

> a Doctour of Phisik,
> In al this worlde was ther non him like. . . .
> He was a very parfit practisour.
>
> Chaucer, *Canterbury Tales*

Erasmus Darwin's early life is known only in the barest outline. He came from a Lincolnshire family, whose lineage has been traced back to the sixteenth century, and he was born at Elston Hall, near Newark in Nottinghamshire, on 12 December 1731. His father, Robert Darwin, was a lawyer whose portrait shows him as a handsome man with strong and rather heavy features. Erasmus described him as follows: 'He was a man of more sense than learning; of very great industry in the law, even after he had no business, nor expectation of any. He was frugal, but not covetous; very tender to his children, but still kept them at an awful kind of distance. He passed through this life with honesty and industry, and brought up seven healthy children to follow his example.' [1] Robert Darwin had married Elizabeth Hill, the mother of these seven healthy children, in 1724. She was twenty years younger than her husband and survived him for forty-three years, dying in 1797 at the age of 95. She is reputed to have been — and it is easy to imagine from her portrait that she was — a capable and scholarly woman, of strong character. Erasmus was the youngest of her four sons. As a child he showed an interest in mechanical curiosities and poetry, tastes which persisted throughout his life; but he didn't much care for taking exercise, a distaste which, combined with a hearty appetite, guaranteed his future corpulence.[2]

At the age of 9 Erasmus was sent to Chesterfield School, where he seems to have liked the masters and to have been quite happy. After nine years there he went up to St. John's College, Cambridge, in 1750, with two elder brothers. The expense of three sons at Cambridge strained their father's resources, and Erasmus had to live frugally and mend his own clothes. The Exeter scholarship which he won, though worth only £16 a year, was probably almost enough to pay for his keep. He studied classics, mathematics and medicine, and passed his examinations with apparent ease but little distinction. At Cambridge he also wrote many poems of little distinction: one of them, *The Death of Prince Frederick*, was republished in the *European Magazine* in 1795.

Medicine was his chosen profession, and, after taking his B.A. at Cambridge in 1754, he went on to complete his training with two years at the leading medical school in Britain, Edinburgh. Here he began a lasting friendship with James Keir, a quiet and discreet man, who later became a distinguished chemist and a leading member of the Lunar Society. Keir's account of Darwin at Edinburgh is severely restrained:

> The classical and literary attainments which he had acquired at Cambridge gave him, when he came to Edinburgh, together with his poetical talents and ready wit, a distinguished superiority among the students there.[3]

Another friend of his Edinburgh days, who tactfully remained anonymous, reported that 'in his youth Dr. Darwin was fond of sacrificing to both Bacchus and Venus; but he soon discovered that he could not continue his devotions to both these deities without destroying his health and constitution. He therefore resolved to relinquish Bacchus, but his affection for Venus was retained to the last period of life.'[4] It was an early attack of gout which induced him to abstain from alcohol.

In 1755 Darwin returned to Cambridge to take his M.B. degree, and in the autumn of 1756, having completed his studies at Edinburgh, he was as well qualified to practise as an eighteenth-century doctor could be. He decided to exercise his talents in familiar territory, at Nottingham. But, as so often, the prophet was without honour in his own land: the people of Nottingham did not choose to let him treat them, and Darwin had ample time to write poems or speculate boldly on matters scientific in letters to a German friend, the son of the philosopher Reimarus.[5] He also became embroiled in dispute with a London surgeon who had overcharged a poor patient. In the end the surgeon paid back two-thirds of the six-guinea fee: the patient was grateful, but the doctors of Nottingham could scarcely have relished the prospect of further such interventions from this recent and unemployed recruit to their ranks.

After two months, however, in November 1756, Darwin abandoned Nottingham in favour of Lichfield, the cathedral city in Staffordshire some fifteen miles north of Birmingham. At this time Lichfield, the home-town of Garrick and Johnson (whose *Dictionary* had been published in the previous year), was more famous than Birmingham, which was only beginning its industrial expansion. Darwin carried a letter of introduction to Canon Seward, whose house in the cathedral Close was the centre of Lichfield's literary life. The Canon, a kindly and learned man, was well known in his time as editor of Beaumont and Fletcher's plays, but his work did not satisfy Coleridge: 'Mr. Seward! Mr Seward! You may be, and I trust you are, an angel; but you were an ass.'[6] Seward's eldest daughter, Anna, who was 13 years old[7] when Darwin arrived, later became famous enough as a poetess to earn the title 'The Swan of Lichfield'. Though Anna's verses are no longer esteemed, her book *Memoirs of the Life of Dr. Darwin* is the chief source for our knowledge of Darwin at Lichfield, and a mine of quaintly phrased stories, some of which may be mythical.[8]

Darwin began his practice at Lichfield brilliantly. Within a few weeks of his arrival a 'young gentleman of family, fortune, and consequence',[9] Mr. Inge, lay dangerously ill, abandoned by the doctors as incurable. In desperation, his family called in the untried newcomer. By a daring and novel course of treatment, Darwin restored his dying patient, who subsequently enjoyed a long and worthy life as a magistrate of the county. This impressive cure made Darwin famous in the neighbourhood, and once launched he never looked back: his fame as a doctor grew with the years until it was legendary. The general applause drowned the voices of the few who complained that his methods were rash and experimental, and his income rose steadily from £192 in 1757 to £726 in 1762.

Anna Seward has drawn a detailed pen-portrait of Darwin in his early years at Lichfield. 'He was somewhat above the middle size, his form athletic, and inclined to corpulence; his limbs too heavy for exact proportion';[10] or, in Edgeworth's blunter phrases, 'He was a large man, fat, and rather clumsy'.[11] His face was severely marked by smallpox and his features were usually 'rather saturnine than sprightly', Anna continues; but he had 'florid health' and 'a sunny smile', which rendered 'that exterior agreeable, to which beauty and symmetry had not been propitious'. He stammered badly, 'but whatever he said, whether gravely or in jest, was always well worth waiting for'.[12] Someone once asked him rather offensively if he did not find stammering very inconvenient. He replied, 'No, Sir, it gives me time for reflection, and saves me from asking impertinent questions'.[13] In conversation he could be something of a despot, according to Anna, even in his early days: he became 'sore upon opposition . . . and always revenged it by sarcasm of very keen edge'.[12] Here was someone worthy to fill the gap left by Johnson's departure twenty years before, and to preserve Lichfield's reputation as the home of tyrannical talkers. Two features of Darwin's conversation seemed surprising to a God-fearing and deep-drinking society: he disdained both Christianity and alcoholic drink. Though he could be formidable, he was more often charming, and most of those who met him for the first time were delighted by his conversation: it was only when he was thwarted or indignant that he indulged in sarcasm.

He had, in Anna's view, a highly poetic imagination, but chose to repress his poetic gifts because they might harm his reputation as a doctor: he had taken warning from the fates of two other poet-physicians, Akenside and Armstrong, whose medical careers could scarcely be called successful. Darwin completed more than thirty years of medical practice before venturing into print with a long poem.

He was exceedingly generous and humane, never taking fees from poor patients and often supplying them with food and other necessities. Benevolence was the quality for which he was most famous. Keir wrote: 'I think all those who knew him, will allow that sympathy and benevolence were the most striking features. . . . In benevolence, he thought that almost all virtue consisted. . . . The communication of happiness and the relief of misery were by him held as the only standard of moral merit.' [14] And Sir Brooke Boothby in one of his sonnets refers to

Darwin . . . whose ever-open door
Draws, like Bethesda's pool, the suffering poor;
Where some fit cure the wretched all obtain
Relieved at once from poverty and pain.[15]

Soon after arriving at Lichfield Darwin fell in love with Mary Howard, whom Anna describes as 'a blooming and lovely young lady of eighteen', with a mind of 'native strength', an 'awakened taste for the works of imagination' and 'ingenuous sweetness'.[16] Darwin married her without publicity on 28 December 1757. Four days previously he wrote her a letter which is typical of his blunt originality: 'Dear Polly, As I was turning over some old mouldy volumes . . . one I found, after blowing the Dust from it . . . to be a Receipt Book. . . . Upon one page was "To make Pye-Crust". . . . Then follow'd "To make a good Wife". "Pshaw", continued I, "an acquaintance of mine, a young Lady of Lichfield, knows how to make this Dish better than any other Person in the World. . . ."' [17] Their marriage seems to have been particularly happy, marred only by Polly's continual ill-health — a trait which showed itself in several of her descendants, including Charles Darwin and three of his children.[18]

In 1758 the Darwins took an old half-timbered house in the cathedral Close, which faced Beacon Street and enjoyed a prospect of 'pleasant and umbrageous fields'. Erasmus renovated the house and transformed the front garden: originally the moat surrounding the Close had run through the garden, and now it was a wilderness, which he converted into a delightful shrubbery. 'The tangled and hollow bottom he cleared into lawny smoothness, and made a terrace on the bank . . . planting the steep declivity with lilacs and rose-bushes.'[19]

In his years at Lichfield Darwin worked long hours at his practice and entertained many friends, the closest of whom was Dr. William Small of Birmingham. Dr. Small, physician and chemist, was a most accomplished man, 'whose strength of reasoning, quickness of invention, learning in the discoveries of other men, and integrity of heart (which is worth them all), had no equal',[20] as Darwin wrote after Small's early death in 1775.

Another great friend of Darwin's was Josiah Wedgwood: although their homes were thirty miles apart, they managed to meet quite often. Born in humble circumstances, Wedgwood had, by thrift, hard work and skill, acquired a business of his own by 1759. Through continual experiment he greatly improved the manufacturing techniques, so that his pottery became world-famous and his name a household word. Wedgwood, though immensely active, was rarely well, and it was probably as a patient that he first met Darwin, in 1760 or 1761. Wedgwood was a great innovator in matters mechanical, and usually sought Darwin's help or advice. For example, they co-operated in working for the establishment of the Trent-and-Mersey Canal (the 'Grand Trunk Canal'), for which a Parliamentary Bill was secured in 1766. In the chemical mysteries of colouring pottery, Darwin was a valued adviser, and when Wedgwood came to plan his new and magnificent works in the late 1760s, it was Darwin who suggested the name 'Etruria' because Wedgwood had, he thought, rediscovered 'a species of non-vitreous encaustic painting' previously known only to the ancient Etruscans.

In 1778 a horizontal windmill of Darwin's design was built at Etruria for grinding colours and mixing clay, and it operated successfully for many years.

Another firm friend of Darwin's was the charming and eccentric Richard Lovell Edgeworth. In 1765, when he was 21, Edgeworth heard that Darwin had invented a new type of carriage, very resistant to overturning. Thus inspired, Edgeworth resolved to become an inventor himself, retired to his house on Hare Hatch Common, near Reading, and produced a long series of ingenious contraptions — an improved carriage of Darwinian type, a robot wooden horse (rather like a modern tank), a carriage with sails, a telegraph, an umbrella for covering haystacks, a turnip-cutter, and many more.[21] These inventions, besides relieving unemployment among the blacksmiths and coachmakers of Reading, won Edgeworth gold and silver medals from the Society for the Encouragement of Arts.

After constructing his first Darwinian carriage in 1766, Edgeworth wrote to Darwin and was invited to Lichfield. He made the journey in a one-wheeled carriage rather like a wheelbarrow back-to-front. On arrival he was entertained by Mrs. Darwin, since her husband was out on his rounds. The doctor returned late in the evening, bringing with him what, at first, in the darkness seemed to be a corpse. It was a man Darwin had found lying in drunken stupor in a ditch, and had brought home to resuscitate. Candles came, and, to the astonishment of the doctor and his wife, the rescued man proved to be Mrs. Darwin's brother, who (unlike his father) had until then apparently been noted for sobriety.[11] This bizarre first meeting left Edgeworth with an indelible impression of Darwin's benevolence. And Darwin was favourably impressed by Edgeworth, referring to him in a letter as 'the greatest conjuror I ever saw. . . . Edgeworth has the principles of nature in his palm, and moulds them as he pleases.'[22] They were lifelong friends, and Edgeworth often visited Lichfield, where he met the second and third of his four wives, the sisters Honora and Elizabeth Sneyd. Darwin's designs for carriages, though pleasing to

Edgeworth, were not entirely successful. One day in 1768 Darwin was pitched out from his carriage and broke his knee-cap. He was slightly lame for the rest of his life as a result.

In 1766 Darwin also made the acquaintance of Rousseau, who was living at Wootton Hall, north of Lichfield. As was his custom, Rousseau was reclining in his cave one day, contemplating the beauty of Nature outside, when Darwin came along and began examining the vegetation with his botanical eye. Rousseau, sensing a kindred spirit, spoke to him, and they later exchanged letters for several years. Though Darwin had many ideas similar to Rousseau's, especially on Nature-study and education, he does not seem to have been directly influenced.

Another, historically the most important, of Darwin's friendships was with James Watt, who called on Darwin during his journey to southern England in 1767, probably because he knew Darwin was keenly interested in steam engines. The shy, unworldly and melancholic Watt found an ideal helper in the confident, optimistic and knowledgeable Darwin, to whom he at once confided his ideas on improving the steam engine. Darwin realized Watt needed the backing of an industrialist to bring his invention into practical service, and it was either Darwin or Dr. Small who introduced Watt to their friend Matthew Boulton, one of the leading manufacturers of England, whose metal works at Soho was a wonder of the Empire. A few years later Watt returned to Birmingham as Boulton's partner, and the Boulton-and-Watt steam engine began its illustrious career. Watt greatly benefited from his friendship with Darwin, who criticized his schemes, supplied him with new ideas and gave him a broader outlook on the world. 'It will be my pride, while I live,' Watt said, 'that I have enjoyed the friendship of such a man.'[23]

Darwin's domestic life continued smoothly through the 1760s, though long hours of work and frequent guests left him little time with his own family. There were five children of this first marriage, and three sons, all 'docile and affectionate',[24] survived infancy, Charles (born 1758), Erasmus (1759) and Robert (1766). Robert, the only one to attain a ripe old age, had mixed memories of his early days. His father punished children chiefly by sarcasm, and Robert, who was abnormally sensitive, still remembered in later life some of his wounding remarks.

When Robert was 4, in 1770, his mother died, aged 31. Her health had always been precarious and she was further weakened by 'the frequency of her maternal situation', as Anna Seward put it. In the weeks before she died she often spoke to Anna about the past, and her happiness with her husband. 'The maladies of my frame were peculiar; the pains in my head and stomach, which no medicine could eradicate, were spasmodic and violent.' [24] Sometimes she was free of pain for several days, and then she felt doubly happy. Her husband's 'indulgence to all my wishes, his active desire to see me amused and happy, proved incessant. . . . Married to any other man, I do not suppose I could have lived a third part of those years which I have passed with Dr. Darwin; he has prolonged my days, and he has blessed them.' [24]

Twenty-two years later, in response to a query from his son Robert, Darwin described his first wife's complaint with clinical detachment: 'She was seized with pain on the left side about the lower edge of the liver, this pain was followed in about an hour by violent convulsions, and these sometimes relieved by great doses of opium, and some wine, which induced intoxication. At other times a temporary delirium, or what by some might be termed insanity, came on for half an hour, and then she became herself again, and the paroxysm was terminated. This disease is called hysteria by some people. I think it allied to epilepsy.' [25] To relieve the pain, she took to drinking spirits and water; Darwin found when it was too late that she had done so in great quantity, and at the end she showed symptoms of liver disease.

Darwin remained a widower during the 1770s, but he did not lack female company. During part of this time his elder sister Susannah kept house for him; and he also 'solaced himself with the society of a lady whose name may or may not have been Parker'.[26] Their two illegitimate daughters, known as the Misses Parker, remained in his household. In the 1790s they set up a boarding school for girls at Ashbourne in Derbyshire with some thirty pupils, and Darwin wrote for them a tract on Female Education.

Anna Seward, now in her early thirties, remained a close friend. Although Anna's beauty matched her talent, if we are to believe Romney's portrait and Southey's remark, 'more beautiful eyes I never saw',[27] Erasmus apparently never considered the possibility of marrying her. In 1780 they wrote playful love-letters on behalf of their cats; but Darwin's Persian, Mr. Snow, was rejected by Anna's Miss Po Felina. This was one of Darwin's ways of relaxing from the rigours and horrors of his medical round:

> Dear Miss Pussey, As I sat, the other day, basking myself in the Dean's Walk, I saw you, in your stately palace, washing your beautiful round face, and elegantly brinded ears, with your velvet paws, and whisking about, with graceful sinuosity, your meandering tail. That treacherous hedgehog, Cupid, concealed himself behind your tabby beauties, and darting one of his too well aimed quills, pierced, O cruel imp! my fluttering heart. . . .[28]

There is much more in the same vein, including some verses beginning:

> Cats I scorn, who, sleek and fat,
> Shiver at a Norway rat;
> Rough and hardy, bold and free,
> Be the cat that's made for me! . . .[28]

Darwin was adept at such humorous semi-nonsense poems, and sometimes they would have a sting:

> Simon did vow, nay he did swear
> He'd dance with none but who were fair,
> Suppose we women should dispense
> Our hands to none but men of sense
> Suppose! Well, Madam, and what then?
> Why, sir, *you'd* never dance again.[29]

Socially, Darwin was at his most active in the 1770s, and one of his closest friends was Thomas Day, author of *Sandford and Merton*, an exceedingly benevolent man and perhaps the oddest of all eighteenth-century eccentrics. After searching long and vainly for a wife, he decided to educate a child in his principles. He chose two girls from an orphanage, and reared them with care and kindness. But his years of indoctrination were fruitless: his *protégées* did not come up to expectations, and had to be pensioned off. With the aid of Dr. Small, Day did eventually find a suitable wife, who became quite devoted to him and his eccentricities. He died, aged 41, in 1789, on being thrown from a vicious horse, which did not respond to his theory of control by kindness. The names of Darwin and Day were often linked, because both were famous for benevolence and originality.

Darwin's old friend James Keir came to live at West Bromwich about 1768, and in the late 1770s founded the Tipton alkali works, which was second only to the Soho factory as a marvel of technology and marks the birth of the modern chemical industry.[30]

Darwin often met Dr. Johnson, but they remained on frosty terms. Johnson might have expected, on returning to his birthplace, to lord it unchallenged. He must have been a little chagrined to find in this obscure provincial town a sage as weighty as himself, and as little inclined to yield in argument, whose 'powers of wit, satire and peculiar humour . . . gained him strong ascendancy in private society',[31] and whose habit of scoffing at Christianity would not have endeared him to Johnson. When he was in Lichfield, Johnson often visited the Sewards, and his stepson Joseph Porter would have married Anna's younger sister but for her untimely death. Even here, however, Johnson was resisted. Anna disliked his dictatorial habits and was not afraid to cross him.[32] Her grandfather had been his headmaster at Lichfield Grammar School, and it was difficult for her family either to see a sage in a schoolboy or to forget his humble origin. (This dislike of a grandfather's pupil is strikingly paralleled by Samuel Butler, whose grandfather, Dr. Butler, was headmaster of Shrewsbury Grammar School when Charles Darwin was a pupil, and who later quarrelled with Charles — on the subject of Erasmus. To complete the chain of coincidence, Dr. Butler became Bishop of Lichfield and occupied the Palace, where Anna lived for over fifty years.)

Johnson was not too pleased at being unable to impress this provincial poetess: he hit back by referring to Lichfield as 'intellectually barren', and remarking (unfairly, it seems) that Canon Seward 'brings himself to the state of a hog in a stye'[33] through being too careful of his health. The all-round antipathy emerges most pointedly in Darwin's scathing couplets about the activities of Johnson and Canon Seward as editors of Shakespeare and Beaumont respectively:

> From Lichfield famed two giant critics come,
> Tremble, ye Poets! hear them! 'Fe, Fo, Fum!'
> By Seward's arm the mangled Beaumont bled,
> And Johnson grinds poor Shakespear's bones for bread.[34]

It seems only fair to let Anna end this paragraph of disparagement with her tart references to Darwin as 'that large mass of genius and sarcasm',[35] and to the schoolboy Johnson as a 'huge, over-grown, mis-shapen, and probably dirty stripling'.[36]

For a short time in the late 1770s Darwin was friendly with Mr. (later Sir) Brooke Boothby. Together they founded the Lichfield Botanic Society, which had only one other member, Mr. Jackson, an industrious man whose life 'was probably shortened by late acquired habits of ebriety',[37] as Anna unkindly remarks. Darwin, though disappointed at the Society's limited membership, saw to it that scientific papers signed 'Lichfield Botanic Society' adorned the periodicals, and scientific travellers who passed through Lichfield often inquired about the state of the town's Botanic Society. One swallow may not make a summer, but one Darwin was enough to make a Society.

The 1770s were the most flourishing years of the 'Lunar Society', the most famous English scientific Society of the seventeenth and eighteenth centuries, if we except the Royal Society. The Lunar Society was founded, probably in 1766, by Darwin, Matthew Boulton and Dr. Small.[38] It had few set rules or regulations, being merely a monthly gathering of a group of men interested in science and technology, held at one or other of their houses. The majority of the group came from near Birmingham, and they met on a day near the full moon, so that after their sessions, which usually lasted from about 2 till 8 p.m., they could have some light when riding home. There were about a dozen members, and each could bring one guest. The shrewd and popular James Keir seems to have most often acted as chairman, and Boulton delighted in entertaining the Society grandly at his house in Birmingham. Another who often acted as host was Samuel Galton, a Quaker and a wealthy industrialist, who, like most of the other members, had a passion for mechanical inventions and experiments: it was his butler who called the members 'Lunatics'. The learned Dr. Small died in 1775 at the early age of 41, and was succeeded both as a member of the Society and in his medical practice by Dr. Withering, who became one of Darwin's few rivals as a physician. Day and Edgeworth frequently attended the meetings, and Wedgwood would come as a guest if he was staying near Birmingham.

The Lunar Society was one of those self-igniting groups whose illuminating ideas stimulate the individual members, and the professional scientists in the Society benefited greatly from the speculations of the others. Joseph Priestley, the greatest scientist among them, dedicated his *Experiments on the Generation of Air from Water* to the Society:

> There are few things that I more regret in consequence of my removal from Birmingham, than the loss of your society. It both encouraged and enlightened me; so that what I did there of a philosophical kind ought in justice to be attributed almost as much to you as to myself. From our cheerful meetings I never absented myself voluntarily, and from my pleasing recollection they will never be absent.[39]

And in a letter he wrote: 'More than ever do I now regret the loss of the *Lunar Society*, where I spent so many happy hours, and for which I found no substitute even in London'.[40] Another who gained much from the Lunar Society was James Watt, and, like Priestley, he never missed a meeting without compelling cause. Among other reputed members were John Baskerville, the printer and typographer, who, although a militant atheist, became famous for his superb Bibles, John Whitehurst, the geologist, and, later, William Murdock, inventor of gaslighting. The most eminent scientists of the day, such as Sir Joseph Banks and Sir William Herschel, attended occasionally as guests.

Darwin delighted in the speculative discussions of the Lunar Society. Sometimes he was too busy to come, and then the host would receive one of his lively letters of apology:

> Dear Boulton, I am sorry the infernal divinities who visit mankind with diseases . . . should have prevented my seeing all your great men at Soho to-day. Lord! what inventions, what wit, what rhetoric, metaphysical, mechanical and pyrotechnical, will be on the wing, bandied like a shuttlecock from one to another of your troup of philosophers! while poor I, I by myself I, imprison'd in a post-chaise, am joggl'd, and jostl'd and bump'd, and bruised along the King's highroad to make war upon a pox or a fever. . . .[41]

It is a pity that the Lunar Society kept no record of its proceedings: for it was, as Darlington remarks, 'intellectually the most effective provincial group that has ever come together in England',[42] and its speculations must have foreshadowed many later advances.

Perhaps the most astonishing feature of the Lunar Society was the way in which the group of friends, Darwin, Wedgwood, Boulton, Watt, Edgeworth, Keir, Day and Priestley (while he was at Birmingham) was each the friend of all the others, and remained so. As one reads in turn biographies of each, the others regularly appear. Edgeworth remarked that the group was 'such a society, as few men have had the good fortune to live with; such an assemblage of friends, as fewer still have had the happiness to possess, and keep through life. . . . This mutual intimacy has never been broken but by death.'[43] The Lunar Society directly inspired scientific advances, but these social contacts of its members had consequences just as important: Galton's son, Samuel Tertius, married Darwin's daughter, Violetta, and one of their sons was Sir Francis Galton, whose pioneering work in eugenics, statistics, psychology, anthropology, meteorology and criminology is so startling in its power and variety; Wedgwood's eldest daughter, Susannah, married Darwin's son Robert, and Charles Darwin was one of their sons.

Darwin was active in other fields too: about 1777 he bought 'a little, wild, umbrageous valley, a mile from Lichfield . . . irriguous from various springs, and swampy from their plenitude . . .'[44] Here he exercised his mechanical and botanic skills to turn the eight acres of swamp into a pleasure garden and herboretum, damming the streams to make lakes, and creating flower-lined walks among the drained marshes. It was a happy blending of two of the eighteenth century's most pleasant arts, those of the naturalist and the landscape-gardener — of Linnaeus and Capability Brown. When Anna saw this bower of botany for the first time she was delighted, and, being left alone because Darwin was called away on an urgent case, she promptly celebrated the occasion in verse:

> Down the steep slopes he led, with modest skill,
> The grassy pathway, and the vagrant rill;
> Stretch'd o'er the marshy vale the willowy mound,
> Where shines the lake amid the cultur'd ground;
> Rais'd the young woodland, smooth'd the wavy green,
> And gave to Beauty all the quiet scene.

Darwin took over these lines, almost word for word and without acknowledgment, at the beginning of his long poem *The Botanic Garden.* Such plagiarism cannot be admired; but in extenuation it is worth remembering that Darwin is believed to have written the best parts of Anna's *Elegy on Captain Cook*, which won her much praise.[45]

In the 1770s Darwin was as active as ever in his medical practice: *active* is the right word, for his patients were scattered over a wide area, and he spent long hours in his carriage, bumping along over the vile roads. It was not time wasted, however, for his 'Sulky' was fitted with a skylight, a pile of books, writing materials and a hamper of food, so that he could read, write or eat *en route*.[46] Dryden's line about another poet-physician, Sir Richard Blackmore,

> He wrote to the rumbling of his chariot wheels,

would apply as well to Darwin. His *entourage* was completed by an old horse, called 'Doctor', trained to follow the carriage. When the roads became impassable, Darwin would get out and complete his journey on Doctor's back.

As the years passed and Darwin's experience grew, so did his fame as a doctor. One of his patients in 1778 was the Countess of Northesk, who happened to stay at Lichfield on her way to Scotland, given up as a hopeless case of continual haemorrhage by the physicians of London and Bath, who had sent her home to die. She was persuaded to consult Darwin, and he took her into his house, where she lay on a couch 'drawing with difficulty that breath which seemed often on the point of final evaporation'.[47] After three weeks of body-and-mind treatment by Darwin, who prescribed a diet of milk, vegetables and fruit, plus continual conversation with a co-operative Anna Seward, the Countess was cured, and thereafter enjoyed good health until she died through setting her clothes alight. Darwin so often restored patients who had been abandoned by other doctors that his reputation of pre-eminence among the physicians of his day is not surprising, and can scarcely be disputed. 'Within the narrow resources of 18th-century medicine, he was supreme.'[48]

Darwin was often accused of subjecting his patients to experimental treatments, and occasionally, no doubt, there was some truth in the charge. But such experiments were most carefully considered beforehand, and often abandoned. With Lady Northesk, for example, he contemplated a blood transfusion, and Anna Seward gallantly offered to be the donor. But the next day he told her that on second thoughts he had decided the process was too hazardous.[49] Another example comes from one of his unsuccessful cases, Edgeworth's second wife Honora, who died of consumption. Edgeworth assures us that Darwin never went beyond the usual treatment without fully discussing the innovation first, and was cautious and even timid in suggesting novel treatment.[50]

Darwin's eldest son Charles was keenly interested in science and showed every sign of following in his father's footsteps: he even had a stammer, though he was partially cured by being sent to France for two years when he was about 8 years old. He went up to Oxford at the age of 16, but was irked by its torpid devotion to classics, and asked to be transferred to Edinburgh. There he was outstandingly able as a medical student, and won the first gold medal of the Aesculapian Society for discovering a criterion 'by which *pus* may be distinguished from *mucus*'. His brilliant promise was tragically ended in 1778, before he was 20. He cut his finger while dissecting; the wound festered, and he died on 15 May. His father, who had reached Edinburgh while Charles was still alive, only to watch him sink, regarded this as the cruellest blow of his life.

1778 marked another and quite different crisis in Darwin's life. In the previous summer one of his patients was Milly Pole, the 3-year-old daughter of Colonel Pole and his wife Elizabeth, of Radburn Hall, near Derby. It was a difficult case — Milly lacked 'animal spirits' and her extremities were always very cold — and the treatment was lengthy. By the spring of 1778, however, Darwin had cured her, and fallen violently in love with her mother, who, according to Anna Seward, was 'in the full bloom of her youth and beauty'. Darwin was no Adonis when young, and now at the age of 46 had grown so corpulent that a semicircular hole had been cut in the table to accommodate him at meals. It was also said that, as he walked along, his tongue used to hang out like a dog's, but this was apparently a slander. Anna remarks indignantly that she 'never witnessed a custom so indecent',[51] though she admits that he 'looks like a butcher' [52] and that he lost his front teeth early, so that when speaking he disclosed both his tongue and the ravages of time. His pursuit of a young and beautiful married woman looked hopeless: but no one was better qualified than Darwin to combat a hopeless case, and he turned a situation which might seem fit only for farce into a tender and romantic idyll.

Darwin began his wooing by sending Elizabeth Pole a tea-vase, and appropriate couplets to go with it:

Vase, when Eliza deigns to pour,
With snowy hand, thy boiling shower;
And sweetly talks, and smiles, and sips
The fragrant steam, with ruby lips,
More charms thy polish'd orb shall shew
Than Titian's glowing pencil drew. . . .[53]

After the first flush of delight, Darwin recognized that the outlook was bleak, and the copious verses quoted by Anna Seward become more sombre:

Dim, distant towers! whose ample roof protects
  All that my beating bosom holds so dear,
Far shining lake! whose silver wave reflects
  Of Nature's fairest forms, the form most fair. . . .[53]

In the autumn of 1778 Elizabeth became ill with a raging fever. Darwin was called in; but, when the crisis came, he was rather pointedly not invited to stay the night, and spent it outside, watching her window. Happily, the patient recovered, and Darwin was not slow to renew his attentions, in an Ode ostensibly addressed to the River Derwent:

O! should Eliza press the morning dew,
And bend her graceful footsteps to your brink . . .
. . . tell her, Derwent, as you murmur by,
How in these wilds with hopeless love I burn,
Teach your lone vales and echoing caves to sigh,
And mix my briny sorrows with your urn. [54]

Anna Seward, who over-valued such verses, compared Darwin's addresses to Elizabeth Pole with Petrarch's poems to Laura, especially since his pursuit seemed likely to be as unsuccessful as Petrarch's.

Within two years, however, in November 1780, Colonel

Pole conveniently died. His widow — rich, young, witty, attractive, gay, and not much interested in matters intellectual — had many of the handsome young bachelors in Derbyshire competing for her hand. Against such rivals, a fat, ugly, stammering widower with children to rear, who was nearly 50 and looked much older, would seem to have no chance. Yet Darwin married her in the spring of 1781: 'the triumph of intellect was complete', says Anna.

The second Mrs. Darwin was born Elizabeth Collier, the illegitimate daughter of Charles Colyear — 'Beau Colyear' — the second Earl of Portmore, and she was brought up at Farnham by a Mrs. Mainwaring, whom she occasionally visited in later life and always spoke of affectionately. Her reputed wit, beauty and carefree ways are reminiscent of her grandmother Catherine Sedley, who had the curious triple distinction of being the daughter of the profligate Sir Charles Sedley (author of such lyrics as 'Phillis is my only joy'), the mistress of James II (and, consequently, Countess of Dorchester), and wife of the worthy General Sir David Colyear, first Earl of Portmore, who served William III so well.[55]

Elizabeth disliked Lichfield, and insisted on living near Derby, some twenty miles to the north-east. So Erasmus said goodbye to Anna and his other friends at Lichfield, abandoned his practice there, and deprived the Lunar Society of his guiding hand; his Botanic Garden reverted to wilderness, and twenty-five years later was known as 'Dr. Darwin's bath',[56] a sad come-down. He seems to have had few regrets, for his second marriage was as happy as the first. By now he was professionally unassailable, and financially secure — his income had reached £1,000 a year by 1771 — and the seven children of his second marriage had very happy childhoods.

For two years after their marriage the Darwins lived at Radburn Hall, an impressive mansion standing in a spacious park, at one corner of which lie the church and hamlet of Radbourne (as it is now known). The church has been associated with the Pole family for nearly 700 years, and the hamlet is still a scene of rural peace, though only four miles west of Derby. In 1783 the Darwins moved into a house near the corner of Full Street, Derby. Their new home might aptly have been called Full House, for by 1790 they had seven children of their own to find room for, as well as the three Pole children and Darwin's illegitimate daughters. Their house has been demolished to allow the widening of Full Street: it stood close to the site of the present police station. But in Darwin's day the house was on the outskirts of the town and had a large garden sloping down to the river, with an orchard beyond, reached by a mechanical ferry of Darwin's design (see Chapter IX). The river was, appropriately, the Derwent, from which the family name 'Darwin' may have originated.[57]

In his years at Derby, Darwin's fame as a doctor became prodigious: to-day, with so much more science and less chance in medicine, it is difficult to appreciate how he was credited with almost magical powers. Even the most pious, although professing to believe no good could come from a sceptic's prescriptions, in practice consented to be cured by him, and patients came from all over the country and from the Continent. Darwin would never migrate to London, though asked to do so by 'countless families of rank and opulence'[58] and by King George III, who was heard to say (over and over again, as was his custom), 'Why does not Dr. Darwin come to London? He shall be my physician if he comes.'[59] Many well-known physicians wrote or came to him for advice when they were baffled. On one famous occasion a man arrived from London, asking Darwin to examine him and give a frank opinion. Darwin found that he was in the last stages of consumption, and had to say that he could only live for about a fortnight. The man thanked him: now he was sure there was no hope.

> 'But as you come from London, why did you not consult Dr. Warren, so celebrated a physician?' asked Darwin.
>
> 'Alas! doctor, I am Dr. Warren,' was the reply. He died a week or two afterwards. . . .[60]

In his later years Darwin became more and more averse to alcoholic drink, having so often seen its dire effects on his patients. Moreover, his propaganda was apparently effective: 'It is well known that Dr. Darwin's influence and example have sobered the county of Derby', Anna tells us; 'intemperance in fermented fluid of every species is almost unknown amongst its gentlemen'.[61] And Maria Edgeworth reported that most of the gentry in his own and neighbouring counties became water-drinkers. It is scarcely possible now to verify these statements, but, if true, they are a convincing proof of his prestige. The brewers of Burton did not go out of business, however, for not all their customers could be called gentlemen. One of these unregenerates provided the cue for a rhyme Darwin wrote for his children:

O mortal man that liv'st by bread!
What makes thy nose to look so red?
'Tis Burton Ale, so strong and stale,
That keeps my nose from growing pale.[62]

As this doggerel shows, Darwin was not solemn or censorious about alcohol; as we shall see in the next chapter, the reasons for his antipathy were medical, not moral.

Darwin himself was not a total abstainer, for he would occasionally drink English wine, well-watered.[63] And there was a notorious occasion early in his career at Lichfield when he signally failed to live up to his precepts. On a hot midsummer day he was persuaded to join a picnic party going by boat along the Trent. After lunch came wine, and Darwin, perhaps tricked into drinking too much, was soon 'in a high state of vinous exhilaration', as Anna puts it. Near Nottingham he surprised the company when without warning he stepped overboard, swam ashore and made for the town, ignoring their calls. Going in search, they found him in the market-place, standing on a tub and addressing a crowd, without a trace of his usual stammer. He was lecturing the populace on the benefits of fresh air, and exhorting them to open their bedroom windows at night. After completing his harangue, he calmly rejoined the party, still slightly damp but otherwise normal. No such escapades are likely in later years; even this one, though too good to suppress, may not be entirely authentic.[64]

With the solitary exception of alcohol, Darwin was far from abstemious. He was a devotee of what is nowadays euphemistically called 'the culture of the abdomen'; not because he remembered that in the Middle Ages Erasmus was patron saint of the abdomen, but because he genuinely believed that heavy eating promoted good health. Its power to build up resistance to the many killer-germs of the time outweighed its general tendency to shorten life, which is emphasized to-day. He apparently ate a fairly normal amount of meat, but he had a huge appetite for fruits, sugar, cream and butter. Galton's daughter Mary Anne (Mrs. SchimmelPenninck) has given a vivid but scarcely credible account of his appetite. Whenever he came, her father had a 'luncheon-table set out with hothouse fruit, and West India sweetmeats, clotted cream, Stilton cheese, etc.' [65] While the conversation went on, 'the dishes in his vicinity were rapidly emptied; but what was my astonishment when, at the end of the three hours during which the meal had lasted, he expressed his joy at hearing the dressing-bell, and hoped dinner would soon be announced'.[65] Mrs. Schimmel-Penninck was often malicious towards Erasmus, and these memories of her childhood must be exaggerated; but at least it shows the impression he made on her.

That the teenage daughter of one of his patients should remember Darwin so vividly in her old age is one of the greatest tributes to the power of his personality. His effect on her was little short of traumatic: a deeply religious little girl, she had to overhear remarks like 'As for the being of a God, the existence of a soul, or a world to come, who can know anything about them? Depend upon it, my dear madam, these are only the bugbears by which men of sense govern fools.' [66] She was 10 years old when she first saw him, and was ready to honour and venerate him for restoring her mother's health. But what did she see? 'His figure was vast and massive, his head was almost buried on his shoulders, and he wore a scratch wig, as it was then called, tied up in a little bob-tail behind. . . .' [65] Though he was physically repulsive to her, she had to admit that 'the doctor's eye was deeply sagacious, the most so I think of any eye I remember ever to have seen . . . his observation was most keen; he constantly detected disease, from his sagacious observation of symptoms apparently so slight as to be unobserved by other doctors. . . . I was astonished at his wit.' [65]

During the 1780s Darwin himself remained in good health, apart from touches of gout, which he combated with his usual vigour. On 10 August 1779 he writes:

> This morning about three I waked with much pain, and tumour, and redness about the joint of the toe. I bled immediately to about 10 or 12 ounces. My pulse was not much quickened nor much hard. About 4 I took calomel, gr. 6. At six this operated. At seven I was very faint and had a slight chillness and 3 or 4 more stools. At eight I put aether repeatedly on the tumid and red part, and kept it from evaporating by a piece of oil'd silk. The pain became less. At nine I set out for Burton; with difficulty got into the chaise. . . .

Such ailments were not allowed to interrupt his rounds. He suffered two more attacks in 1780, and seven years later he records:

> After eating much salt ham, and drinking near a pint of beer, contrary to my custom, having many years totally abstained from spiritous drink, I felt a debility at night, and next day had a little gout. The next more, still more on the third. Took six grains of calomel and had but one restless night. The top of the foot and right toe swelled considerably.[67]

These quotations are from his Commonplace Book, a weighty manuscript volume kept at Down House, Kent, which contains details of medical cases, sketches of many inventions and various other notes on matters which interested him.

In his later years Darwin was still keen to promote scientific societies. The Lichfield Botanic Society was defunct, and he now rarely attended the meetings of the Lunar Society, since Derby was thirty-five miles from Birmingham. As he complained in a letter, 'I am here cut off from the milk of science, which flows in such redundant streams from your learned Lunatics, and which, I can assure you, is a very great regret to me'.[68] He partly made up for the lack by founding the Philosophical Society of Derby in 1783, and guiding its affairs for many years. This Society was unpretentious, being little more than a regular social gathering at which science was the main topic for discussion. Darwin told Boulton how once they tried communicating by balloon with the Lunar Society: 'we sent your society an air-balloon, which was calculated to have fallen in your garden at Soho; but the wicked wind carried to Sir Edward Littletons'.[69] Though some of its activities were light-hearted, the Society built up a useful library and continued organizing lectures until 1857, when it was merged with the Derby Museum and Library.

Darwin was at his most active as an author during his years at Derby. His poem *The Botanic Garden*, begun in 1779, was published in two parts, Part II, *The Loves of the Plants*, appearing in 1789, and Part I, *The Economy of Vegetation*, in 1791. He reversed the order of publication because he thought Part II, though inferior to Part I, was easier to read. Part II was enough to rouse a gratifying chorus of praise, and earned him a high reputation as a poet. The medical treatise *Zoonomia*, which he had been working on since 1771, was published in two massive volumes, the first in 1794 and the second in 1796. It too was received with acclaim, and reached a third edition by 1801, a remarkable feat for so weighty a tome. In 1800 came *Phytologia*, an agricultural treatise, and finally his poem *The Temple of Nature*, published posthumously in 1803. These books will be discussed in later chapters.

One other book, his tract *A Plan for the Conduct of Female Education in Boarding Schools* (1797), can appropriately be described now. When his daughters the Misses Parker set up their school at Ashbourne in the 1790s, Darwin wrote down his ideas on how a boarding school should be run. They found his advice useful and persuaded him to publish it. The book has forty numbered sections, covering all aspects of boarding-school life from Music to Morals, from Arithmetic to Beds. It is eminently practical and rich in common sense; and its banality is relieved by a few ingenious or advanced suggestions. For example, Darwin advocates a slope of 1 in 5 on desks for ease in writing, and suggests narrowing chimneys slightly, above the fire, to prevent too much heat escaping, and opening bedroom windows a little for ventilation. He gives good advice on diet, emphasizing the value of milk and ripe fruit, and he recommends skating, swimming and tight-rope walking for exercise. He thinks school is better than education at home because children express their passions in their faces and, by observing this in his fellows, a child learns to interpret facial expressions, an accomplishment of great value in later life. By and large, this rather unexpected book can best be described as worthy, with a few flashes of brilliance.

When Darwin moved to Derby, his second son, Erasmus, went with him and practised there as a lawyer. Erasmus junior was clever, gentle, sensitive and rather melancholy; he had at first wished to enter the Church, but his father's sarcasm deterred him. A slight antagonism not uncommon between father and son seems to have persisted, and Erasmus never really took to the law, being more interested in and expert at genealogy, statistics and collecting coins. His genealogical work was highly praised by Karl Pearson, and his census of Lichfield also attracted much favourable notice. He never married, and in 1799, when he was 40, he became needlessly worried about money, and drowned himself by walking into the River Derwent one stormy evening. It was a tragedy which darkened the few remaining years of his father's life.

Darwin's third son, Robert, set up as a doctor in Shrewsbury in 1786.[70] Though rather too sensitive to enjoy his profession, he was most sympathetic and observant, and he established one of the finest practices in England, reaping the fruits of it for over fifty years. Not particularly original himself, Robert relied a good deal on his father, and greatly respected not only his medical knowledge, but also his scientific theories and general ideas: for example, Robert abstained from alcohol and any belief in the supernatural, and he followed his father's psychosomatic treatments, suggesting to ladies with vague complaints that they were suffering in their minds. As he grew older, Robert became more like his father: though always kind, he was a formidable figure, a voluble and somewhat pontifical conversationalist, who stood 6 feet 2 inches tall, and weighed 24 stone.[71] He was, apart from his unpublicized atheism, the very model of a paterfamilias, and had an immense influence on his own son Charles. What Robert did or thought was 'absolutely true, right, and wise'[72] for Charles, who even followed his father's example by marrying a Wedgwood.

Robert and Erasmus got on well together, because Robert was wise enough to seek, rather than to resent, the professional advice which his father was uniquely qualified to give: they corresponded frequently and visited each other from time to time. Erasmus had hoped his eldest son, Charles, would enjoy a brilliant scientific career, and when Charles died those hopes were transferred to Robert. Despite his father's help, however, Robert could not generate the essential spark of creativity, as Erasmus implied in a letter to Jonas Dryander: 'I must now beg another favor of you, which is to give your suffrage to my Son, Dr. Robt. W. Darwin, whom I wish to be a member of the Royal Society, which might add new spirit to his industry in philosophical pursuits. . . .'[73] Though this would now scarcely be thought a valid reason for election to the Royal Society, Robert duly became a Fellow in 1788, thus beginning a son-follows-father tradition which was maintained until the death of Sir Charles Darwin in 1962, and is unique in the annals of the Society.

Of the seven children of Erasmus's second marriage, only two lived to old age. Little is known of the eldest, Edward, who was born in 1782 and died unmarried in 1829. The second child was Violetta (1783–1874), the mother of Sir Francis Galton. The third child, Emma, died in 1818. The fourth was Sir Francis Sacheverel Darwin (1786–1859), who was trained as a doctor, shared his father's curiosity about Nature and was also a great traveller. The fifth child, John, became Rector of Elston, and died unmarried in 1818. The sixth child died as an infant. The seventh, Harriot, born in 1790, was married in 1811 to Admiral Maling, and died abroad in 1825.

As the years passed, Erasmus Darwin grew even more friendly with Josiah Wedgwood and his family. In 1786 Wedgwood borrowed the Portland Vase from the Duke of Portland, and after much arduous experiment at last succeeded in making his first good copy in 1789. He promptly sent the copy to Darwin, who called it 'a jewel' and celebrated his friend's achievements in his poem *The Botanic Garden*:

> Whether, O Friend of Art! your gems derive
> Fine forms from Greece, and fabled Gods revive;
> Or bid from modern life the Portrait breathe,
> And bind round Honour's brow the laurel wreath;
> Buoyant shall sail, with Fame's historic page,
> Each fair medallion o'er the wrecks of age . . .[74]

Wedgwood's name will always be linked with the Vase, his finest work; Darwin has also won himself a secure place in its story by proposing what is still regarded as the best of the many explanations of the scene it depicts.[75] He believed the figures on the Vase represent a ritual of death and rebirth deriving from the Eleusinian mysteries, and he expounds this view in convincing detail in a long Note to the *Botanic Garden*.[76]

The Wedgwoods often came to stay at Derby, and Josiah's daughter Susannah was a great favourite with Erasmus. He was delighted to be her pupil for lessons in music, one of the very few subjects on which he was ignorant. It was in 1796 that Susannah married Robert Darwin, thus setting the fashion for the Darwin-Wedgwood marriages in the next generation.

Darwin and Wedgwood were both famous in their later years for their attacks on slavery, as typified by the tirades in *The Botanic Garden*[77] and Wedgwood's medallion of a negro slave in chains, with its telling inscription 'Am I not a man and a brother?' As his attitude to slavery suggests, Darwin was strongly liberal in his political views. He hoped the American Revolution would succeed, and even in 1791 he was still prepared to celebrate the French Revolution as a revival of Liberty:

> Long had the Giant-form [Liberty] on GALLIA's plains
> Inglorious slept, unconscious of his chains;
> Round his large limbs were wound a thousand strings
> By the weak hands of Confessors and Kings. . . .
> Touch'd by the patriot-flame, he rent amazed
> The flimsy bonds. . . .[78]

It was sentiments like these, and especially perhaps the side-swipe at 'Confessors and Kings', which provoked the attacks on him by the *Anti-Jacobin* and other Tory periodicals.

Though his views were often radical and even subversive, Darwin was not deeply interested in political events, and appears to have taken little notice of the three famous radical books of the early 1790s, Mary Wollstonecraft's *Rights of Woman*, Tom Paine's *Rights of Man*, and William Godwin's *Political Justice*. This neglect is surprising, for Darwin had both private and public links with the authors. Godwin was a close friend of Josiah Wedgwood's son Tom (the first photographer, who was a well-known benefactor of impecunious writers), and Everina Wollstonecraft, Mary's sister, was governess to the Wedgwoods in the 1790s. Moreover, Darwin's *Zoonomia* was often bracketed with such 'atheistic' writings as *Political Justice* and Paine's *Age of Reason*[79] for castigation by defenders of the faith; and the *Anti-Jacobin*'s parody, *The Loves of the Triangles*, attacks Godwin, in the form of 'Mr. Higgins', the alleged author of the parody, just as much as Darwin. Godwin called on the Darwins in 1797, two months before his wife Mary Wollstonecraft died after the birth of the daughter who later became Mary Shelley. Darwin was away at Shrewsbury when Godwin called, and so two of the most incisive and radical thinkers of the late eighteenth century failed to meet. Godwin later regretted he did not wait for the return of Darwin, whom he called 'so extraordinary a man, so truly a phenomenon'. 'We paid our respects, however, to his wife,' Godwin goes on, 'who is still a fine woman, and cannot be more than 50. She is perfectly unembarrassed, and tolerably well-bred.'[80]

Another of Tom Wedgwood's pensioners, whom Darwin did meet, in 1796, was Coleridge. As we have already noted, Coleridge admired Darwin's powers, but, like Mrs. Schimmel-Penninck, he was upset by Darwin's attacks on Christianity: 'Dr. Darwin is an extraordinary man, and received me very courteously — He had heard that I was a Unitarian, and bantered incessantly on the subject of Religion. . . . When he talks on any other subject, he is a wonderfully entertaining and instructive old man.'[81]

Though Darwin never associated with Godwin or Paine, he was very friendly with one subversive writer of the 1790s, Dr. Thomas Beddoes. In 1788 Beddoes became lecturer in Chemistry at Oxford University, and succeeded in attracting to his lectures audiences larger, it was said, than any seen there since the thirteenth century. In 1792, however, he resigned his post, after publishing a pamphlet praising the French Revolution and attacking the Church. He moved to Bristol, where in 1798, with financial help from Tom Wedgwood, he founded the Pneumatic Institution, and had the distinction of taking on as his assistant the young Humphry Davy, who was a friend of Watt's son Gregory. Beddoes believed — and in this he was supported by Darwin — that some diseases, consumption in particular, could be combated by making the patient breathe air mixed with oxygen, or perhaps other gases. This pioneer of the oxygen tent married Edgeworth's daughter Anna, and the poet T. L. Beddoes was their son. Dr. Beddoes himself wrote a long poem *Alexander's Expedition*, an imitation of Darwin's *Botanic Garden*, and many shorter poems. He kept up an extensive correspondence with Darwin, chiefly on scientific matters,[82] and in 1793 he published a lengthy *Letter to Dr. Darwin, on a new mode of treating Pulmonary Consumption*. Beddoes also won the esteem of Wordsworth, and of Coleridge, who felt his death 'like a bodily blow': 'For Beddoes was good and beneficent to all men; but to me he had always been kind and affectionate, and latterly I had become attached to him with a personal tenderness'.[83]

Coleridge, like many others, coupled Beddoes and Darwin as materialists; but the link between them was much stronger than this, being forged of their common interests in science, medicine and liberty.

After Josiah Wedgwood's death in 1795, Darwin rarely met his old friends, apart from the ever-youthful Edgeworth, who had recently married for the fourth time. He and his daughter Maria stayed with the Darwins in 1799. Maria was delighted with Darwin, who was now 67: she thought his stammer added to his charm, and called him 'the common friend of genius and of goodness, which he had the happy talent of discovering, attracting, and attaching'.[84] She also liked Elizabeth very much: 'there was so much heart, and so little constraint or affectation in all she said and did and looked'.[85] Darwin and Edgeworth were still busy with new inventions. Edgeworth had settled in Ireland and had successfully completed a scheme of Darwin's for bog-drainage, as well as experimenting with telegraphy and railways.

In 1801 Darwin had a serious illness, and never recovered his old verve. Early in 1802 he moved out of Derby, to Breadsall Priory, about four miles to the north-east. 'We have a pleasant house, a good garden, ponds full of fish, and a pleasing valley somewhat like Shenstone's — deep, umbrageous, and with a talkative stream running down it', he wrote to Edgeworth. 'Our house is near the top of the valley, well screened by hills from the east and north, and open to the south. . . .' [86] But Darwin did not live long to enjoy his new home, and never finished his letter to Edgeworth. He died suddenly, apparently of a heart attack, on 18 April 1802, aged 70.[87] Elizabeth continued to live at Breadsall Priory for thirty years after her husband's death, and to her Galton grandchildren it became known as 'Happiness Hall', so much did they enjoy their frequent visits.

The only monument to Erasmus, apart from a tablet which Elizabeth set up in his memory in Breadsall Church, is the memorial by Onslow Ford in Lichfield Cathedral, which Francis Galton commissioned in 1886.[88] There are appropriate plaques outside Darwin's house in Lichfield and at Derby on the main bridge by the Council House. His friend Joseph Wright painted two portraits of Erasmus, the one reproduced as frontispiece to this book, and another which can be seen in the Derby Museum. In the Darwin Memorial at Down House, one room is largely devoted to Erasmus.

NOTES TO III: LIFE STORY

The following abbreviations are made:

Ashmun=M. Ashmun, *The Singing Swan.* New Haven, 1931.
Bolton=H. Carrington Bolton, *Scientific Correspondence of Joseph Priestley.* New York, 1892.
Darlington=C. D. Darlington, *Darwin's Place in History.* Oxford, 1959.
C. Darwin=Charles Darwin, *The Life of Erasmus Darwin.* 2nd ed., London, 1887.
Edgeworth=R. L. and Maria Edgeworth, *Memoirs of Richard Lovell Edgeworth.* 3rd ed., London, 1844.
Logan=J. V. Logan, *The Poetry and Aesthetics of Erasmus Darwin.* Princeton, 1936.
H. Pearson=H. Pearson, *Doctor Darwin.* London, 1930.
SchimmelPenninck=C. C. Hankin (ed.), *Life of Mary Anne SchimmelPenninck.* London, 1858. 2 vols.
Seward=Anna Seward, *Memoirs of the Life of Dr. Darwin.* London, 1804.

1. C. Darwin, p. 14.
2. See C. Darwin, p. 6. For details of the Darwin family, and portraits, see K. Pearson, *Life of Galton*, vol. I, especially Plate E (pedigree) and Plates III, VI, VII.
3. C. Darwin, p. 13.
4. *Monthly Magazine*, vol. xiii, p. 458 (1802).
5. C. Darwin, pp. 16-17.
6. Coleridge, *Lectures on Shakespeare, etc.* (Dent, 1907), p. 191.
7. Anna Seward was born 12 December 1742, though most reference books give 1747: see Ashmun, pp. 4-7.
8. See C. Darwin, pp. 20, 70-4. Erasmus was fortunate in his first three biographers: Anna Seward's book, though flawed, is 'a minor classic' (E. Sewell, *The Orphic Voice*, p. 223); his second and third biographers were his grandson Charles (who based his excellent factual *Life* on family papers), and that master of lively biography Hesketh Pearson (who is his great-great-great-grandson).
9. Seward, p. 8.
10. Seward, p. 1.
11. Edgeworth, p. 102.
12. Seward, p. 2.
13. C. Darwin, p. 40.
14. C. Darwin, p. 35.
15. Quoted in C. Darwin, p. 63.
16. Seward, p. 10.

17. C. Darwin, pp. 21-2.
18. See Gwen Raverat, *Period Piece* (1952), p. 122.
19. Seward, p. 15.
20. T. W. Peck and K. D. Wilkinson, *William Withering*, p. 1. See also J. Bronowski and B. Mazlish, *The Western Intellectual Tradition* (1960), p. 331.
21. See Edgeworth, pp. 105-11.
22. H. Pearson, p. 45.
23. Quoted in H. Pearson, p. 117.
24. Seward, pp. 12-14.
25. C. Darwin, *Autobiography*, p. 224.
26. H. Pearson, p. 154.
27. Quoted by Ashmun, p. 263.
28. Seward, pp. 134, 137.
29. Unpublished poem quoted by Logan, p. 98.
30. See J. K. Moilliet, *Life of Keir*, pp. 75-6; W. H. B. Court, *The Rise of the Midland Industries* (1938), pp. 229-31; and R. E. Schofield, *Isis*, **47**, 414 (1957).
31. Edgeworth, p. 299.
32. See Boswell, *Life of Johnson* (O.U.P., 1904), II. 219-20.
33. Boswell, *Life of Johnson*, II. 116. See Ashmun, p. 190.
34. C. Darwin, p. 41.
35. T. S. Whalley, *Journals and Correspondence*, I. 381.
36. H. Pearson (ed.), *The Swan of Lichfield* (1936), p. 36.
37. Seward, p. 98.
38. For the history of the Lunar Society, see Bolton, Appendix II; T. W. Peck and K. D. Wilkinson, *William Withering*, pp. 123-40; and R. E. Schofield, *Annals of Science*, **12**, 118-36 (1956): Professor Schofield's *History of the Lunar Society of Birmingham* is due to be published (by O.U.P.) in 1963 or 1964.
39. Quoted from H. Pearson, p. 129.
40. Bolton, p. 148.
41. Bolton, p. 199, and E. Robinson, *Annals of Science*, **9**, 359 (1953).
42. Darlington, p. 12. For a review of the members' scientific activities, see R. E. Schofield, *Isis*, **47**, 408-15 (1957).
43. Edgeworth, pp. 116-17.
44. Seward, p. 125.
45. See Seward, pp. 128-32; Edgeworth, p. 399; and Ashmun, pp. 74-6.
46. For details, see SchimmelPenninck, I. 151, and N. Barlow, *Notes and Records of the Royal Society*, vol. 14, no. 1, p. 86.
47. Seward, pp. 109-10.
48. H. Williams, *Great Biologists*, p. 80; see also Darlington, p. 8, and H. Pearson, p. 172.
49. Seward, pp. 111-13.
50. Edgeworth, pp. 234-5.
51. Seward, p. 425.
52. T. S. Whalley, *Journals and Correspondence*, I. 342.
53. Seward, pp. 106-7.
54. Seward, pp. 121-2.
55. For portraits and details of Elizabeth's family, see K. Pearson, *Life of Galton*, I. 18-22.
56. See T. Harwood, *History and Antiquities of Lichfield* (1806), p. 453.
57. See F. Darwin, *Life and Letters of Charles Darwin*, I. 1.
58. Seward, p. 151.
59. C. Darwin, p. 69.
60. After C. Darwin, p. 106.
61. Seward, p. 5.

62. Quoted by H. Pearson, p. 203.
63. See C. Darwin, *Autobiography*, p. 225.
64. See C. Darwin, pp. 58-9.
65. SchimmelPenninck, I. 152-4.
66. SchimmelPenninck, I. 242.
67. Commonplace Book, p. 89 (13 Nov. 1787).
68. Bolton, p. 202.
69. See E. Robinson's account of the Derby Philosophical Society, *Annals of Science*, **9**, 359-67 (1953). See also F. W. Shurlock, *Science Progress*, **18**, 447-53 (1924).
70. The story that Robert had only £20 to begin his practice is misleading; see preface to C. Darwin, *Life of E. Darwin*, 2nd edition.
71. Based on C. Darwin, *Autobiography*, pp. 28-42.
72. *Emma Darwin. A Century of Family Letters* (ed. H. Litchfield) (1915), I. 140.
73. *Nature*, **189**, 424 (1961).
74. *Economy of Vegetation*, II. 341-6.
75. See W. Mankowitz, *The Portland Vase and the Wedgwood Copies* (1952), pp. 58-9.
76. See *Economy of Vegetation*, II. 321-40, and Additional Note XXII.
77. *Economy of Vegetation*, II. 413-30, and *Loves of the Plants*, III. 435-68.
78. *Economy of Vegetation*, II. 377-80, 385-6.
79. See N. Garfinkle, *Journ. Hist. Ideas*, **16**, 387 (1955).
80. C. Kegan Paul, *William Godwin, his friends and contemporaries* (1876), I. 261.
81. Coleridge, *Letters*, I. 178-9.
82. 13 pages of extracts from this correspondence are given by J. E. Stock, *Life of Thomas Beddoes*, Appendix 6.
83. Coleridge, *Letters*, III. 171.
84. Edgeworth, p. 334.
85. H. Pearson, p. 218.
86. Edgeworth, p. 396.
87. For the date of Darwin's death, see Logan, p. 11.
88. See K. Pearson, *Life of Galton*, II. 204.

IV

ANIMAL AND VEGETABLE

The living fabric now in pieces take,
Of ev'ry part due observation make.
SIR RICHARD BLACKMORE, *Creation*

1

DARWIN expounds his views on animal life in *Zoonomia*, which was published in two massive volumes totalling 1,377 pages, Volume I appearing in 1794 and Volume II in 1796. He explores vegetable life just as thoroughly in *Phytologia* (1800).

Zoonomia, or the Laws of Organic Life taps the accumulated wisdom of a lifetime of medical practice; but it is far more than a treatise on medicine. Darwin ranges over general biology and psychology, and also ventures gaily into philosophy, religion and physics. He studied 'the phenomenon of man', and was far ahead of his time in linking bodily and mental health. From his long and open-minded scrutiny of man, he hoped to discover the laws of organic life, as the title implies, and 'to unravel the theory of diseases' (I. 1).* With these high aims, he codified all human actions in an elaborate system of Classes, Orders, Genera and Species, after the fashion of Linnaeus in botany, and he obviously hoped that this *magnum opus*, by bringing order into a chaos of empirical and barbaric practices, would establish him as a Linnaeus of medicine.

Secure in our knowledge of later medical advances, we can see that Darwin had no chance of being thus acclaimed. His classification was faulty, and he could only have set it right by anticipating Pasteur and adopting the germ theory of disease — which he did come near to discovering, as the following remarks show. 'Thus one grain of variolous matter, inserted by inoculation, shall in about seven days stimulate the system into unnatural action; which in about seven days more produces ten thousand times the quantity of a similar material thrown out on the skin in pustules!'[1] But Darwin never made what now seems the obvious deduction from this and many similar observations: he attributed the great increase to 'imitation', a sort of sympathetic irritation, rather than to germs multiplying. This surrender to abstraction, so common in the eighteenth century, was surprising in Darwin, because he always emphasized the importance of reproduction and the vast increases in numbers which it could cause, as we shall see in the next chapter. He also went half-way towards the germ theory when predicting that microscopy, which was in his day despised as a mere triviality, would have a great future: 'I hope that microscopic researches may again excite the attention of philosophers, as unforeseen advantages may probably be derived from them, like the discovery of a new world'.[2]

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* Numbers in brackets indicate volume and page number in the first edition of *Zoonomia*.

There is much of interest in *Zoonomia*, despite the flaws in its basic classification; and the section on evolution, which will be discussed separately in Chapter V, has an honoured place, though less than it deserves, in the history of science.

During Darwin's own life *Zoonomia* enjoyed great success, and had a wide influence, especially on the treatment of fevers and insanity.[3] It 'was translated into German, French and Italian, and was honoured by the Pope by being placed in the *Index Expurgatorius*',[4] as Charles Darwin wittily remarked. Within ten years, four British editions and two American had appeared. Dr. Beddoes thought *Zoonomia* was 'perhaps the most original work ever composed by mortal man', which would 'place the Author amongst the greatest of mankind, the founders of sciences'.[5] Another sign of the book's fame is the appearance within four years of

Thomas Brown's 560-page critical commentary, *Observations on the Zoonomia of Erasmus Darwin*: very few scientific books, if any, have evoked such a lengthy riposte so promptly.

Before looking at the better features of *Zoonomia*, Darwin's method of classification must be briefly described and dismissed. He divides all bodily action, and diseases, into four classes, which he calls Irritation, Sensation, Volition and Association. *Irritation* covers actions directly caused by external objects, *e.g.* the stomach being activated by an influx of food. *Sensation* describes actions motivated by sensual pleasure or pain, *e.g.* the increased flow of saliva on seeing food. *Volition* includes all voluntary motions of the body, so that convulsions, for example, are among the diseases of volition. *Association* refers to motions which are excited by other muscular activity, as when we learn a sequence of actions, like running or swimming. This classification, which owes a good deal to another famous provincial doctor, Hartley, has serious faults, which Brown rightly condemned in his *Observations*.[6] It rests upon abstractions and not upon tangible medical facts, and is therefore confusingly vague: a particular action or disease can often be assigned to several classes, and unrelated diseases spring into spurious proximity. It is only fair to add, however, first, that Darwin himself assigned each disease to its proper niche with ease; second, that the system is far more defensible philosophically than medically[7]; and, third, that it does point towards some medical truths — *e.g.* Darwin's idea of association comes near to that of the conditioned reflex. The classification is not too obtrusive in Volume I, which is the more general. Only in the detailed catalogue of Volume II does it become all-pervasive.

Volume I of *Zoonomia* is wide-ranging in its topics, though not so encyclopaedic as Darwin's poems. One of his favourite subjects is '*ocular spectra*', the images left on the retina after gazing intently at a coloured pattern. If, for example, you stare at a circular yellow patch for about a minute, and then cover your eyes, you will see a violet after-image of the same size and shape; if the original is red, the after-image is green; if the original is blue, the after-image is orange. There is a chapter by Darwin himself on this topic, in which he makes some acute deductions about the functioning of the retina, and also a long paper by his son Robert, reprinted from the *Philosophical Transactions* of the Royal Society. Robert wrote no other scientific papers of interest, and his father probably helped him a good deal with this one, which was apparently the first on the subject and won praise from Goethe.[8] The pioneering researches of Darwin-and-son on after-images were extended by Goethe and Helmholtz; but the subject was then neglected for almost a century and has only recently been revived.

Often, however, Erasmus favoured bold speculation rather than detailed research, and he was particularly fond of trying to link different sciences. Sometimes he succeeded, as when he correctly described oxygen's rôle in the blood circulation, thereby linking chemistry and physiology, at a time when chemistry was still under the thrall of the phlogiston theory. At other times he failed, as when trying to link astronomy with disease. Impressed by the way sleep follows a solar rhythm and menstruation a lunar one, he was misled into seeing solar and lunar influences where there were none. Floundering in the morass of ignorance about disease, he strenuously sought a pattern and, like the observers who managed to see the markings on Mars as straight canals, he strove too hard. In his time atmospheric tides raised by the sun and moon were greatly overrated,[9] and he wrongly attributed to them the daily rhythm shown by some diseases.

Another fallacious idea was Darwin's explanation of beauty, a subject dear to the eighteenth century, studied in theory by Hogarth in his *Analysis of Beauty* and by Burke in his essay *On the Sublime and Beautiful*, and in practice by the great landscape-gardeners.

> All these various kinds of pleasure at length become associated with the form of the mother's breast; which the infant embraces with its hands, presses with its lips, and watches with its eyes. . . . And hence at our maturer years, when any object of vision is

> presented to us, which by its waving or spiral lines bears any similitude to the form of the female bosom, whether it be found in a landscape with soft gradations of rising and descending surface, or in the forms of some antique vases, or in other works of the pencil or the chissel, we feel a general glow of delight, which seems to influence all our senses. . . . And thus we find, according to the ingenious idea of Hogarth, that the waving lines of beauty were originally taken from the temple of Venus. (I. 145-6)

To which Sheridan replied, 'I suppose that the child brought up by hand would feel all these emotions at the sight of a wooden spoon'.[10] This objection, together with thirteen others given by Brown,[11] shows how Darwin, despite his flair for stripping the veneer of familiarity from common objects to reveal an underlying truth, was sometimes blind to the fallacies in his theories.

Darwin correctly foresaw the future importance of electricity, at a time when it had the status only of a toy. It was the invention of the Voltaic cell in 1800 which led to the recognition of current electricity and thence to the modern era of electric power. The Voltaic cell depends on the discovery that if plates of two different metals, such as lead and zinc, are dipped in a conducting solution, a continuous electric current will flow along a wire attached to the dry ends. Darwin was writing before 1800, but he sensed the importance of Volta's earlier experiments, remarking that if pieces of lead and silver, touching outside the mouth, are applied to different parts of the tongue, an acidulous taste is noticed 'as of a fluid like a stream of electricity passing from one of them to the other' (I. 120). He believed that this 'deserves further investigation, as it may acquaint us with new properties of matter' — which it certainly has.

Darwin also boldly suggested in *The Botanic Garden* (1791) that nerve impulses were electrical,[12] a fact which was not established until after 1850. Consequently he took great interest in the experiments on muscular contraction by Galvani and Volta later in the 1790s.

In using electricity to cure disease, too, Darwin was a bold innovator, and his experimental treatments often succeeded. He quotes the case of a Mr. S., who had jaundice for about six weeks, and derived no benefit from physic:

> [He] had taken emetics, cathartics, mercurials, bitters, chalybeates, essential oil, and ether, without apparent advantage. On a supposition that the obstruction of the bile might be owing to the paralysis, or torpid action of the common bile-duct, and the stimulants taken into the stomach seeming to have no effect, I directed half a score smart electric shocks from a coated bottle, which held about a quart, to be passed through the liver, and along the course of the common gall-duct, as near as could be guessed, and on that very day the stools became yellow; he continued the electric shocks a few days more, and his skin gradually became clear. (I. 348)

Some of Darwin's experimental inoculations are horrifying to read about. For example, he inoculated his son Robert and a baby daughter against measles, with the result that both caught it severely, and for this disease at least he abandoned the method. It is easy to mount our twentieth-century high horse and condemn Darwin for continually risking his patients' lives. But this is unfair criticism, because (1) his experimental methods saved far more patients than they killed, (2) he was cautious in using them, as we have seen in Chapter III, and (3) the standard methods were no less horrifying. Diseases which resisted the combined power of cathartics, emetics, bleeding and a strong constitution were usually fatal in the eighteenth century: 'the patient generally dies after a few days' is a recurrent refrain in *Zoonomia*. A strong constitution was vital, as is evident when we read, 'both recovered by repeated bleeding' (I. 281) and 'the lancet is the anchor of hope in this disease' (pneumonia) (II. 197). In these conditions almost any well-thought-out experiment was worthwhile, and would sometimes be a genuine advance, as, for example, when he used foxglove to treat dropsy.[13]

Zoonomia shows that Darwin opposed alcoholic drink chiefly because of the many awful examples of chronic alcoholism and alcoholic poisoning he saw among his patients. In the section 'On Drunkenness' he sums up his experience, unleashing a welter of technical horrors which might daunt anyone not already gripped by the habit.

> . . . in drunken people it generally happens that the secretory vessels of the liver become first paralytic, and a torpor with consequent gall-stones or schirrus of this viscus is induced with concomitant jaundice; otherwise it becomes inflamed . . . and produces the gout, or the rosy eruption of the face, or some other leprous eruption on the head, or arms, or legs. Sometimes the stomach is first affected, and paralysis of the lacteal system is induced; whence a total abhorrence from flesh-food, and general emaciation. In others the lymphatic system is affected with paralysis, and dropsy is the consequence. In some inebriates the torpor of the liver produces pain without apparent schirrus, or gall-stones, or inflammation, or consequent gout, and in these epilepsy or insanity are often the consequence. All which will be more fully treated of in the course of the work. (I. 246-7)

After such a tirade it is no surprise to find Darwin favouring an alcoholic interpretation of the myth of Prometheus: 'the after punishment of those who steal this accursed fire is a vulture gnawing the liver; and well allegorizes the poor inebriate lingering for years under painful hepatic diseases'. (I. 353)

Despite his attacks on alcohol, Darwin would often prescribe it. For example, he proposes the following bizarre medicines to combat malignant scarlet fever: 'A vomit once. Wine. Beer. Cyder. Opium. Bark, in small repeated doses. . . .' (II. 245) In his treatment of advanced alcoholics, too, he was both practical and humane. He would tell patients to omit one-quarter of their customary potation; if after a fortnight their appetites improved, another quarter should be omitted; and so on. But if their digestions suffered, they should go on as they are 'and rather bear the ills they have, than risk the encounter of greater'. For, as Darwin gloomily remarks, 'where the power of digestion in these patients is totally destroyed, there is not much reason to expect a return to healthful vigour' (I. 100).

Volume II of *Zoonomia*, despite its fallacious basis, is a fascinating case-book. Darwin assigns all diseases to his four main Classes, each Class being divided into various Orders, each Order into Genera, and each Genus into Species. He lists 474 diseases, often with actual cases for illustration, and prescribes treatment (or sometimes, even, a cure) for each.

To give an idea of Darwin's system, it is worth quoting one group of species, and the very first will serve as well as any:

> Class 1. Diseases of Irritation
> Ordo 1. Increased irritation
> Genus 1. With increased actions of the sanguiferous system.
> Species: 1. Irritative fever; 2. Drunkenness; 3. Arterial haemorrhage; 4. Spitting of arterial blood; 5. Bleeding from the nose. (II. 3)

The diseases listed are so diverse that the catalogue might even be called entertaining. It includes Laughter and Sleep (both diseases of volition); Purple Spots and Lice (both, aptly enough, diseases of irritation); Itch and Indigestion; Smallpox and Sentimental Love.

Darwin has effective remedies for many minor ailments; but when a graver disease attacks, he usually calls up his battery of dubious all-purpose cures. These are: first and foremost, venesection (bleeding), either by lancet or by leeches; purgatives, of which calomel is perhaps the favourite; emetics, ranging from tartar to digitalis; opiates, such as opium and laudanum; and the Peruvian bark (quinine). He is at his best, however, when he steers clear of these stock medicines. For example, when faced with cancer, he remarks that the only hope is surgery at a very early stage. If the disease is allowed to develop too far, nothing will avail. A second example is childbirth, on which he is up-to-date:

> As parturition is a natural, not a morbid process, no medicine should be given, where there is no appearance of disease. The absurd custom of giving a powerful opiate without indication to all women, as soon as they are delivered, is, I make no doubt, frequently attended with injurious, and sometimes with fatal consequences. (II. 189)

Darwin's experimental cures often appear, with question marks, at the end of his list of orthodox remedies. He would have nodded in approval at oxygen tents and modern electrotherapy, for one of his speculative treatments is: 'Could oxygene gas mixed with common air stimulate the languid system? Small electric shocks through the tonsils every hour? . . .' (II. 246) And if we think his electrical treatment sounds a bit tough on the patient, we should remember it was directed against a disease (malignant scarlet fever) of which 'the patient generally dies in a few days'.

The eighteenth century seems to have been prone to convulsions, and Darwin, obviously well-versed in the subject, gave patients the full treatment:

> Venesection. An emetic. A cathartic with calomel. Warm-bath. Opium in large quantities, beginning with smaller ones. Mercurial frictions. Electricity. Cold-bath in the paroxysm; or cold aspersion. (II. 327)

One cannot help wondering whether the knowledge of what was in store aggravated the patient's convulsions. Still, this treatment was, no doubt, more appropriate for convulsions than for, say, smallpox.

Though most of Darwin's alleged remedies for physical disease do not now command respect, he seems acute and up-to-date in treating psychosomatic ailments. He was one of the first to insist on the link between bodily and mental health, a link which had somehow become forgotten in civilized societies. Even to-day in general practice the treatment of the patient as a complete individual — a body-plus-mind — does not always come up to Darwin's standards.

Darwin was also a pioneer in recognizing and treating mild mental illness. It was not until after 1900 that neuroses and psychoses came again on to the medical register, and many mental oddities which greatly influence us are still little studied. Under the heading of *ambitio* or inordinate love of fame, Darwin ridicules the idea of military glory; his 20-page discourse on sleep and dreams remains acceptable to-day; he devotes two pages of acute analysis to *erotomania* or sentimental love, an apparently incurable complaint; and he creates a disease called *Pulchritudinis desiderium* so that he can denounce the many cosmetics containing lead, which poisoned their wearers.

In serious mental illness, Darwin's great virtue was his sympathy with the victims, at a time when the standard treatment was brutality. Take, for example, his gentle comment on a case of hallucination:

> [Miss G——] said, as I once sat by her, 'My head is fallen off, see it is rolled to that corner of the room, and the little black dog is nibbling the nose off'. On my walking to the place which she looked at, and returning, and assuring her that her nose was unhurt, she became pacified, though I was doubtful whether she attended to me. (II. 361-2)

If necessary, however, he could be tough. For example, when called in to treat a woman with obsessional jealousy of her husband's first wife, whose portrait she destroyed, he talked pointedly in his most sarcastic vein, all through the hearty meal he received on arrival, about the virtues of the first wife and the defects of the second (his patient), who was staggered at his tirade. He then left, telling the husband that if ever again she behaved oddly he should threaten to send for Dr. Darwin. It was never necessary: she was cured.[14]

Darwin was particularly sympathetic towards the victims of religious mania, and angry with those who caused it. Although in *Zoonomia* he often refers to the 'Great First Cause' with apparent sincerity, he was scornful of organized religion, and he included Credulity, Superstitious Hope and the Fear of Hell in his catalogue of diseases. He complains of an 'intellectual cowardice instilled into the minds of the people from their infancy': 'credulity is made an indispensable virtue' and inquiry is held to be more sinful than moral crimes. The cure for credulity is 'to increase our knowledge of the laws of nature', 'to emancipate ourselves from the false impressions which we have imbibed in our infancy, and to set the faculty of reason above that of imagination' (II. 410-11). He is particularly scathing about *Spes* *religiosa*, the hope of pleasing God by self-inflicted wounds, and quotes the lamentable case of a local clergyman who gradually beat himself to death. Even more deplorable is *Orci timor*, fear of hell:

> Many theatric preachers among the Methodists successfully inspire this terror, and live comfortably upon the folly of their hearers. In this kind of madness the poor patients frequently commit suicide; although they believe they run headlong into the hell, which they dread! Such is the power of oratory, and such the debility of the human understanding! (II. 379)

It is a difficult disease to cure:

> Where the intellectual cowardice is great, the voice of reason is ineffectual; but that of ridicule may save many from those mad-making doctors; though it is too weak to cure those, who are already hallucinated. Foot's Farces are recommended for this purpose. (II. 379)

Zoonomia is a mixture of grim and gay. At times Darwin harps on the dark side of eighteenth-century life: 'among the poor children of Derby who are thus fed [on gruel], hundreds are starved into the scrophula, and either perish, or live in a state of wretched debility' (II. 27). Obviously there was a pressing need for the dispensary he established in the town. Sometimes, on the other hand, his recipes are seasoned with wit. For *Satyriasis*, or 'ungovernable desire of venereal indulgence', his complete treatment is: 'Venesection. Cathartics. Torpentia. Marriage' (II. 380). For the trembling victims of *Pallor et tremor a timore* he advocates 'Opium. Wine. Food. Joy' (II. 524). A topic he might have been expected to take seriously, stammering, is treated almost casually. He gives a plausible cure, which may have provoked the reply 'Ph-physician, heal thyself' from Bible-quoting patients.

Darwin's linking of body and mind has, in addition to its practical importance, earned him a small niche, next to Hartley, in the history of philosophy. As G. H. Lewes remarked, Darwin 'aimed at establishing the physiological basis of mental phenomena' and 'deserves a place in history for that one admirable conception'.[15] In *Zoonomia* he points out how the images constituting memory and imagination, far from being mere abstractions, must have a physiological locale: 'Where is this extensive canvas hung up?' he inquires — a question which the brain specialists have not yet fully answered. Darwin also stresses the importance of repetition and imitation in building up memory and imagination.

Volume II of *Zoonomia* concludes with 118 pages on the 'Articles of the Materia Medica', that is, the complete eighteenth-century medicine chest, comprising 'all those substances which may contribute to the restoration of health' (II. 657). This inventory shows that cathartics, purgatives and opiates were but a small fraction of a rich though ineffective store of medicines. Darwin divides the Materia Medica into classes — Nutrientia, Incitantia, and five others whose names we need not rehearse. He again casts his net much wider than most physicians. The Nutrientia are chiefly foods, but water is included because, he says, it is the chief food of plants, which retain the hydrogen and breathe out the oxygen. Typical Incitantia are alcohol and opium, but they have to fraternize with oxygen gas, love and joy.

Zoonomia took many years to write: 'a great part of this work has lain by the writer above twenty years', awaiting revision which never came, Darwin says. He made no apology for theorizing: 'to think is to theorize . . . and happy therefore is the patient, whose physician possesses the best theory' (I. 2). He hoped his own theory would provide at least 'a foundation and a scaffolding, which may enable future industry to erect a solid and a beautiful edifice . . .' (II. 625). On one topic, evolution, this hope has been amply fulfilled, as we shall see in the next chapter; but his main classification has not survived, despite his many insights into the future.

Apart from the evolutionary section, four features of *Zoonomia* seem impressive to-day. First, there is the linking of body and mind: as a concept, this deserves notice in the history of philosophy; as a medical working-rule, it provides a rare example of Darwin still being ahead of some modern general practice. Second, we have to admire his bold experimental cures, for they succeeded often enough to earn him a near-legendary reputation. Third, he anticipated future discoveries, as when he suggested nerve-impulses were electrical. Finally, there is his pioneer work in treating mental illness humanely instead of brutally.

2

In *Zoonomia*'s companion volume *Phytologia*, which runs to over 600 pages, Darwin expounds the laws of vegetable life, and shows how they should be applied to agriculture and gardening. Though medicine was his profession, Darwin seems to have known as much as anyone of his time about botany, gardening and the principles of agriculture; and since these subjects were more securely grounded than medicine, *Phytologia* has fewer flaws than *Zoonomia*. As usual, Darwin enlivens the book with scintillating ideas, and states without proof the gist of various later discoveries.

Phytologia (the word means 'the study of plants') is systematically laid out. Part I deals with the physiology of vegetation — the functions of buds, roots, seeds, leaves and the reproductive systems. Part II covers practical economic aspects of agriculture, particularly manure, drainage and diseases. In Part III we are told how to secure good yields of fruit, seeds, root-crops, timber and flowers. From this cornucopia I shall pick out a few of Darwin's many illuminating or original remarks, ignoring what might be called routine gardening lore.

He begins his account of vegetable physiology by emphasizing that 'vegetables are in reality an inferior order of animals' (p. 1) and physiologically similar: thus, the leaves of plants are their lungs, as Hales noted, and, like an animal's lungs, have a huge surface area. The great difference is that vegetables are stationary, and have to find nourishment in the ground, whereas animals, being locomotive, eat the food conveniently stored for them in vegetables or other animals. He also stresses, and was apparently the first to do so,[16] that a plant consists of 'a system of individual buds' and not a multiplication of similar organs.

Darwin seizes on the recent discoveries by Priestley and others about the absorption and emission of gases by plants, but goes beyond Priestley's phlogiston-bound outlook to the truth. He notes that by day plants absorb carbon dioxide and emit oxygen, while their root-systems absorb water and mineral nutriment. He also outlines the chemical processes of plant nutrition — the formation of sugars and oxygen from the combination of water and carbon dioxide in the presence of sunlight. He sees the 'sugar-making process carried on in vegetable vessels' as 'the great source of life to all organized beings',[17] which animals utilize when they eat the vegetables. There are minor flaws in his account: for example, he thought the carbon dioxide was absorbed mainly by the roots, in aqueous solution. But he was well ahead of his contemporaries, extending the ideas of Ingenhousz, anticipating those of Liebig, and foreshadowing the modern view of photosynthesis.

Equally original were Darwin's studies of the 'muscles, nerves and brain of vegetables'. He describes various insectivorous plants, such as the amazing *Dionoea muscipula*, Venus's fly-trap, which closes its leaves over insects like a steel-trap and proceeds to digest them,[18] showing in Darwin's view that it has sense organs to detect the marauding insects, nerves to transmit the information to a 'brain', and muscles in its leaves to grasp the unfortunate insect. To test his hypothesis that there is 'a common sensorium, or brain, where the nerves communicate', he slit a leaflet of mimosa 'with sharp scissars, and some seconds of time elapsed, before the plant seemed sensible of the injury; and then the whole plant collapsed as far as the principal stem'. The mimosa closes and retracts wounded leaflets, just 'as I draw away my hand when my finger is hurt'. He concludes that individual buds of plants have sensation and volition, 'though in a much inferior degree even than the cold-blooded animals' (p. 133). He also discusses *Hedysarum gyrans*, which whirls its leaves when the air is still; climbing plants; the turning of the upper sides of leaves to the light; and certain courtship antics of pistils and stamens. All confirm him in his belief of a common sensorium, and supply the logical basis for the much-laughed-at *Loves of the Plants*.

I shall reserve for later discussion three of the most pregnant sections of *Phytologia*. The first, on the reproduction of vegetables, serves as a protracted footnote to *The Loves of the Plants* and figures in Chapter VI. In the second Darwin argues that sexual reproduction is superior to asexual because it allows the development of variety, a circumstance which is 'employed to great advantage by skilful gardeners' (p. 26). This topic belongs to Chapter V, as does the third, which is the key to Darwin's philosophy of life, namely the idea that vegetables, like animals, derive pleasure from the functioning of their vascular systems.

The second part of *Phytologia* is a fine practical guide to several aspects of agriculture. Agricultural chemistry had been little studied and was largely founded by Darwin's book, though soon to be further advanced by Davy. Darwin is at his best in his dissertation on Manures, which runs to 25,000 words and is almost a book in itself. Since vegetables are but a lower form of animals, he says, they need the same elements as animals for nutrition, and these can best be provided by decaying animal or vegetable matter. He discusses in turn the various substances he thinks are required — air, water, carbon, phosphorus, lime, and others such as chlorides and nitre. He also refers to the fertilizing properties of bone-dust, which, although previously noticed, 'were first theoretically explained and brought forward with authority by Dr. Darwin', in the opinion of Sir John Sinclair, President of the Board of Agriculture.[19] He then considers how to supply the manures, and enunciates the maxim 'Burn nothing which may nourish vegetables by its slow decomposition beneath the soil' (p. 244). All decaying vegetation should go back to the land as manure.

He then applies these admirable principles of husbandry, deploring the waste of 'the manures of towns and cities, which are all now left buried in deep wells, or carried away by soughs into the rivers'. Instead he advocates sewage farms, and his advice has now been generally followed in

England, though the archaic eighteenth-century methods still survive, especially in seaside towns. He proposed two reforms in graveyards, of which one has been accepted and the other is still too radical. Church graveyards should be discontinued, he says, and 'proper burial grounds should be consecrated out of towns'. These should be divided into two sections, 'the earth from one of which, saturated with animal decomposition, should be taken away once in ten or twenty years, for the purposes of agriculture . . .' (pp. 242-3).

Darwin's contributions to practical agriculture do not end with manure: he illuminates several other subjects. He tells us in a nonchalant 30-page chapter just how to drain and water land, exploiting to the full his appreciation of the vagaries of geological strata, in which he was far ahead of orthodox thought in the nascent science of geology, as we shall see in Chapter VI. He describes in detail an improved version of Tull's drill plough, which he claims is simpler and more accurate 'than any drill plough at present in use'. Darwin set great store by this device, which figures in the book's subtitle, and certainly it seems ingenious and workable, like most of his inventions. But I do not know whether it was ever widely used.

The third part of *Phytologia,* dealing with the production of plants and vegetables, is mostly of little interest to-day, though I confess that one very unprofessional gardener of the twentieth century has benefited from its advice. Darwin provides a practical handbook for gardeners, woodmen and fruit-growers — a type of book now familiar as a paperback in pocket editions: but it would need a gargantuan pocket to house the 165 cubic inches of *Phytologia.*

The mass of gardening hints and agriculture advice is shot through with many Darwinian shafts. The practice of excluding light, etiolation, often used for keeping celery pale, inspires a comparison with 'the etiolated young ladies of some boarding schools', who are kept indoors too much. He suggests that the tape-worm disease of American water-rats might be imported to keep down British rats, a policy recently paralleled half-intentionally by myxomatosis and rabbits. He argues that man should eat a mixture of vegetable and animal food, because his teeth and the length of his intestines are both intermediate between those of carnivorous and herbivorous animals.

This must conclude our sketch of *Phytologia*. Darwin gave it an alternative title, *The Philosophy of Gardening and Agriculture*, and he succeeds admirably in his aim of providing a scientific basis for these subjects. The book deserved to have a wide influence, but, in fact, probably had little, for there was no second edition. Though it can hardly be recommended as light reading to-day, any persevering reader of it would, I think, be deeply impressed by the scope of Darwin's knowledge and his insight into mysteries which time has unveiled. He well deserved Sir Humphry Davy's tribute to him as one of 'the most enlightened philosophers who have studied the physiology of vegetation'.[20]

NOTES TO IV: ANIMAL AND VEGETABLE

1. *The Temple of Nature*, Additional Note VIII, p. 38.
2. *The Temple of Nature*, Additional Note I, p. 11.
3. C. Darwin, pp. 105-8.
4. C. Darwin, p. 102.
5. J. E. Stock, *Life of Thomas Beddoes*, pp. 131, 133.
6. T. Brown, *Observations on the Zoonomia*, pp. 25-69.
7. See Logan, chap. 2.
8. See C. Darwin, p. 84, and J. M. Drachman, *Studies in the Literature of Natural Science*, p. 161.
9. See L. Howard, *The Climate of London* (2nd ed., 1833), I. 158-9.
10. G. H. Lewes, *History of Philosophy*, II. 364.
11. T. Brown, *Observations on the Zoonomia*, pp. 294-302. Logan (pp. 54-64) also discusses Darwin's theory of beauty.
12. *Economy of Vegetation*, I. 367, note.
13. Darwin was apparently the first doctor to treat dropsy with foxglove (see C. Hutton *et al.*, *Philosophical Transactions abridged*, vol. 15, p. 290; and Seward, p. 324). Withering systematized the treatment, in his *Account of the Foxglove* (1785).
14. See C. Darwin, p. 42.
15. G. H. Lewes, *History of Philosophy*, II. 356, 357-8. See also Logan, pp. 21-45.
16. C. Darwin, pp. 111-12.
17. *The Temple of Nature*, IV. 66, note.
18. See F. E. Lloyd, *The Carnivorous Plants* (1942), pp. 177-94.
19. J. Sinclair, *Life and Works of Sir John Sinclair* (Edinburgh, 1837), II. 84-5.
20. H. Davy, *Collected Works* (1840), VII. 182.

V

THE THEORY OF EVOLUTION

He saw the multitudinous hosts of life,
All creatures of the sea and earth and air,
Ascending from one living spiral thread,
Through tracts of time, unreckonable in years.
ALFRED NOYES, *The Torch-Bearers*

1

SINCE the word evolution has, down the centuries, acquired so many meanings, we must begin by defining it. In this chapter *evolution* refers to the development of organic types from earlier distinct yet related types; but it should be remembered that neither Erasmus nor Charles Darwin used the word in this sense when propounding their theories of what we now call evolution, since before 1860 the prime meaning of the word was quite different.[1] Historically, the theory of evolution, with its claim that species are variable, stood opposed to the theory of special creation, according to which species remain unchanged in form and any new ones arise as an 'act of God'. Yet this antithesis, despite the bitter controversy it once aroused, always had a touch of unreality about it, since no one has ever defined a species exactly.

The theory of evolution has a long history, which we must now briefly review if we are to assess Erasmus Darwin's contribution.

The concept of evolution stems from the ancient Greeks, who, with their usual acumen, foretold in speculative form many aspects of the modern theory. The belief that life originated in water goes back to Thales, about 600 B.C.; and Anaximander (611–547 B.C.) thought that men developed, by gradual stages, from fish. Anaximenes (588–524 B.C.) was one of the first to suggest that life began spontaneously in primordial slime, an idea accepted by many later Greeks, such as Parmenides, Democritus and Anaxagoras. Speculations like these, and the influential view of Heraclitus that everything is in a state of flux, provided fertile ground for the growth of evolutionary ideas. The theory was first properly outlined by Empedocles (495–435 B.C.), who held that life developed gradually, plants preceded animals, and more perfect forms replaced the imperfect, which died out. His views were summed up as follows by Aristotle: 'Where chance brought about the sort of combination that might have been arranged on purpose, the creatures, having been suitably formed by chance, survived; but those which were not so formed perished, and still perish'.[2] Aristotle makes this summary only with the aim of refuting it: 'but it is impossible that this should be the way of it', he says. For, although among the greatest of biologists, he opposed the evolutionary theories of his predecessors. Nevertheless, he did define a concept which now seems like a step on the road to evolution, his 'Ladder of Nature'. Man is at the top of the ladder, the other mammals next, then the cetaceans, reptiles and fish, cephalopods, crustaceans, and so on, down through plants to inanimate matter. Aristotle stresses the small differences between these classes: for example, it is difficult to tell whether certain sea-dwellers are animal or vegetable. But he fails to draw the conclusion that the plant and animal kingdoms have similar ancestors. In the ancient world after Aristotle, the chief evolutionists are Epicurus and Lucretius, but they added little to the previous speculations.[3]

As the influence of the Greeks declined, so did the open-minded approach to Nature. In the 1,500 years after Aristotle, when Christian teaching became dominant in Europe, basic questions about life were answered by an appeal to authority rather than by speculation. The Book of Genesis, taken literally, supported the special-creation theory; but Augustine preferred a roundabout interpretation of Genesis, which brought him near to an evolutionary view, and Aquinas followed, more or less, in his footsteps. So, in the Middle Ages, a belief in evolution was not odiously heretical. Indeed, two Biblical episodes might seem to require it. First, there was the delicate problem of Adam, whose progeny must have suffered at least some change of colour if he was the ancestor of white, yellow and black races: this conclusion could only be avoided by making either the unpleasant assumption that only the whites were descended from him, or the unsupported speculation that Adam was white and Eve black — their offspring, like those of Miss Starkey in the limerick, being 'One black, one white and two khaki'. The second relevant Biblical story was that of Noah: as emphasized by Buteo (1559) and Daneau (1575),[4] species must formerly have been much fewer, if Noah really did take two of each in his ark. Despite the dissension aroused by Adam and Noah, literal interpretation of Genesis won the day, and from 1600 until after 1850 special creation was the orthodox Christian teaching.

The idea of evolution did not lapse when the Christians turned away from it, for the renaissance of the spirit of inquiry into nature brought new advocates of evolution, including Raleigh, Francis Bacon, Ray and Leibniz. And man's affinity to the apes was emphasized in Tyson's *Orang-Outang sive Homo Sylvestris* (1699). The question was only of academic interest, however, until in 1735 and after, Linnaeus proposed his binomial classification of plants and animals, which seemed to imply the fixity of species.

'Are species fixed or variable?' remained perhaps not a burning question, but at least a smouldering one, during the rest of the eighteenth century. Linnaeus himself, combining piety with a natural desire not to undermine his own system, usually tended to regard species as fixed: there are, he said, as many species as issued in pairs from the hands of the Creator. The second famous naturalist of the century, Buffon, whose 44-volume *Natural History* had an immense vogue, often discussed the question and mentioned most of the factors later seized on as important, but expressed such a bewildering variety of opinions that he must be regarded not as an advocate of either view but as a stimulator of discussion.[5] Another famous eighteenth-century figure, Kant, is sometimes held to be one of the early evolutionists, but this view has been convincingly refuted by A. O. Lovejoy.[5] Between 1740 and 1790 there were many, most notably perhaps Diderot, De Maillet and Goethe, who believed that species were variable: but their beliefs, like those of the ancient Greeks, cannot be regarded as more than intelligent speculation.

More important than any of these was Maupertuis (1698–1759), whose discoveries in various branches of science seem never to have received the credit they deserve, chiefly because of Voltaire's antagonism. His contributions to evolution and genetics occur in three books published between 1745 and 1751. The species we now see, he said, 'are but a small part of all those that a blind destiny has produced'; for only those animals which were well adapted to their environment would survive. He developed a theory of heredity in terms of elementary particles derived from both mother and father, and worked out the mathematical probabilities. Though his only experimental material was six-fingered families, he virtually forestalled Mendel by a hundred years, and went beyond him by foreseeing mutations and their effects. His remarks on the variation of species sound like a modern geneticist talking about chromosomes:

> [Variations in species] could have owed their first origination only to certain fortuitous productions, in which the elementary particles failed to retain the order they possessed in the father and mother animals; each degree of error would have produced a new species; and by reason of repeated deviations would have arrived at the infinite diversity of animals that we see to-day. . . .[6]

It was only after Mendel's work was rediscovered in 1900 that any better formulation of this factor in evolution was achieved. Despite these speculative insights, Maupertuis offered no real-life evidence of evolution in action.

2

In the late eighteenth century the theory of evolution, if it was to make any headway, needed a strong advocate who would specify a mechanism for the process, would show how it operated in nature and would not be afraid to outrage conventional opinion and the Church. Buffon was well-placed to fill this rôle, but either did not believe in the theory or, if he did, was unwilling to defy convention: the Church asked him to say he opposed evolution, and he complied. The credit for first propounding a well-rounded theory of evolution, with examples in support, belongs instead to Erasmus Darwin. As Darlington puts it, 'A decisive pattern, a convincing argument, however, appeared for the first time only in the work of [Charles] Darwin's grandfather at the end of the eighteenth century'.[7]

Erasmus Darwin first explained the processes of evolution in section 39 of *Zoonomia*, entitled 'Of generation', though he had believed in evolution for many years, probably since 1771. He begins perversely by putting forward the view (which would have sabotaged his evolutionary theory) that in the foetus the male provided the active nucleus and the female merely the food on which it grows. But fortunately he modifies this view when, after pondering over the mule, he admits that the female contributes almost equally to the make-up of the progeny.[8] He rejects the theory of preformation, then widely held — the theory that the embryo is, as it were, a scaled-down version of an adult — and suggests that the embryo consists of a living filament having no structural resemblance to a man, which gradually acquires new parts as it grows.

Then Darwin draws attention to the great changes which occur in animals. First, there are the changes during the life of an individual animal 'as in the production of the butterfly with painted wings from the crawling caterpillar; or of the respiring frog from the subnatant tadpole . . .' (I. 500).* Secondly, like his grandson in the *Origin of*

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* Numbers in brackets indicate volume and page number in the first edition of *Zoonomia*.

Species, he specially emphasizes the great changes which have, down the centuries, been produced in animals 'by artificial or accidental cultivation, as in horses, which we have exercised for the different purposes of strength or swiftness, in carrying burthens or in running races' (I. 500); or in the various breeds of dog, the bulldog for strength and courage, the greyhound for speed; and so on, with many further detailed examples, including cattle, pigeons, sheep and camels. Further evidence of change, as he noted in *The Botanic Garden*,[9] is provided by the useless rudimentary organs. Thirdly, he discusses monstrous births, and notes the crucial point that the monstrosities, or mutations as we should now say, may be inherited: 'Many of these enormities of shape are propagated, and continued as a variety at least, if not as a new species of animal. I have seen a breed of cats with an additional claw on every foot; of poultry also with an additional claw, and with wings to their feet. . . . Mr. Buffon mentions a breed of dogs without tails' (I. 501). All these undeniable examples of anatomical changes and the similar structure of the warm-blooded animals lead him

> to conclude that they have alike been produced from a similar living filament. In some this filament in its advance to maturity has acquired hands and fingers, with a fine sense of touch, as in mankind. In others it has acquired claws or talons, as in tygers and eagles. In others, toes with an intervening web, or membrane, as in seals and geese. . . . (I. 502)

— with much more in the same vein.

With these many examples to back him up, he feels justified in asserting that 'all animals undergo perpetual transformations, which are in part produced by their own exertions' (I. 502) and in part by their environment. He believes that 'many of these acquired forms or propensities are transmitted to their posterity' (I. 503). This statement is important because it seems to be the first recognition that some variations must be inherited if evolution is to come about.

Having established that variations can and do occur, Darwin discusses in more detail the forces controlling evolutionary change. If adequate supplies of air and water are available, 'the three great objects of desire, which have changed the forms of many animals by their exertions to gratify them, are those of lust, hunger, and security' (I. 503). He then deals with each of these three topics in turn. His exposition of sexual selection can scarcely be bettered:

> A great want of one part of the animal world has consisted in the desire of the exclusive possession of the females; and these have acquired weapons to combat each other for this purpose, as the very thick, shield-like, horny skin on the shoulder of the boar is a defence only against animals of his own species, who strike obliquely upwards, nor are his tushes for other purposes, except to defend himself, as he is not naturally a carnivorous animal. So the horns of the stag are sharp to offend his adversary, but are branched for the purpose of parrying or receiving the thrusts of horns similar to his own, and have therefore been formed for the purpose of combating other stags for the exclusive possession of the females; who are observed, like the ladies in the times of chivalry, to attend the car of the victor. (I. 503)

Similar conclusions apply to the spurs carried by polygamous birds, such as the cock and the quail:

> It is certain that these weapons are not provided for their defence against other adversaries, because the females of these species are without this armour. (I. 503)

Though sexual selection in the narrow sense — the ornaments, special weapons, etc. — is of limited significance, it is in its wider sense a vital feature of evolution by natural selection: for the fittest animals tend to have more progeny, and that progeny, which also will be fitter than average, forms an increased proportion of the next generation. Darwin seizes this point, and concludes with a remark which, though too black-and-white to be entirely true, sums up the essence of natural selection:

> The final cause of this contest amongst the males seems to be, that the strongest and most active animal should propagate the species, which should thence become improved. (I. 503)

The second of the controlling forces is the 'means of procuring food, which has diversified the forms of all species of animals'. Darwin explains how each animal has become adapted to its method of acquiring food, quoting the hard nose of the swine, the elephant's trunk, the rough tongues of cattle, and the peculiarities of birds, which were later to impress Charles Darwin in the Galapagos Islands.

> Some birds have acquired harder beaks to crack nuts, as the parrot. Others have acquired beaks adapted to break the harder seeds, as sparrows. Others for the softer seeds of flowers, or the buds of trees, as the finches. Other birds have acquired long beaks to penetrate the moister soils in search of insects or roots, as woodcocks; and others broad ones to filtrate the water of lakes, and to retain aquatic insects. All which seem to have been gradually produced during many generations by the perpetual endeavour of the creatures to supply the want of food. (I. 504)

Darwin then passes to the third of the controlling forces, the want of security, or the means of escaping other more powerful animals, a want which 'seems much to have diversified the forms of their bodies and the colour of them'. The diversity of form is obvious: 'some animals have acquired wings instead of legs, as the smaller birds, for the purpose of escape. Others great length of fin, or of membrane, as the flying fish, and the bat. Others great swiftness of foot, as the hare. Others have acquired hard or armed shells, as the tortoise and the echinus marinus' (I. 504). The importance of colour is also explained further: 'The colours of many animals seem adapted to their purposes of concealing themselves either to avoid danger, or to spring upon their prey' (I. 509). As he remarked in *The Botanic Garden*, 'Fish, which are generally suspended in water, and swallows, which are generally suspended in air, have their backs the colour of the distant ground, and their bellies of the sky'.[10] Darwin duly notes that protective adaptation, as it would now be called, extends to vegetables, 'as is seen in the wonderful and various means of their concealing or defending their honey from insects, and their seeds from birds'. The attackers' answer is the 'proboscis of admirable structure . . . acquired by the bee, the moth, and the humming bird, for the purpose of plundering the nectaries of flowers' (I. 504). Darwin concludes that these special organs have been called into existence 'by the necessities of the creatures which possess them, and on which their existence depends' (I. 505).

After thus meditating on the similarity of structure in animals, and the changes they undergo, often in a relatively minute period of time, Darwin concludes:

> Would it be too bold to imagine, that in the great length of time since the earth began to exist, perhaps millions of ages before the commencement of the history of mankind, would it be too bold to imagine, that all warm-blooded animals have arisen from one living filament, which THE GREAT FIRST CAUSE endued with animality, with the power of acquiring new parts, attended with new propensities, directed by irritations, sensations, volitions, and associations; and thus possessing the faculty of continuing to improve by its own inherent activity, and of delivering down those improvements by generation to its posterity, world without end! (I. 505)

This rhetorical outburst has several interesting features. Its outline of evolution is the best that had then been given, though the mechanism is left unspecified. At one point, where the account is rather vague, Darwin later improved his wording, in a note to *The Temple of Nature*, where the sentence about warm-blooded animals arising from one living filament is changed to: 'all vegetables and animals now existing were originally derived from the smallest microscopic ones, formed by spontaneous vitality' in primeval oceans.[11] Darwin's ideas are thus in accord with the orthodox modern view that life is most likely to have begun in the sea, with amino-acids being compounded from simpler substances under the action of solar radiation or lightning. In the 'nutrient broth' thus created, little droplets formed and by interacting with their environment probably began the processes of life.[12]

A second point of interest in Darwin's outburst is the tactful wording. He fully appreciated both the religious implications of evolution, which later convulsed the Victorians, and the need to express those implications obliquely, so as to avoid offending Christians. He averts suspicion of atheism by referring, like a good Deist, to 'the Great First Cause'. But he also wishes to imply that evolution, once started, needs no divine aid; so he puts in the phrase *by its own inherent activity*, meaning *without any intervention by God.* (This is worth emphasizing, because the phrase could be misread as implying that animals actively control their own evolutionary progress.)

Another feature of Darwin's exposition is his insistence on the very great age of the earth, without which evolution is scarcely credible. He favoured a long time-scale because he believed most rocks were laid down very slowly, as sediments under the sea, and not formed in sudden catastrophes, as was generally thought in his day. Since the real time-scale is about 4,000 million years, Darwin's 'millions of ages', which implies about 1000 million years,[13] is far better than the 6,000 years which was generally accepted at the time, or the 20–40 million years into which Charles Darwin was forced to try to compress evolution.[14] Another point emerging from Darwin's exposition, his belief that evolution is continually leading to something *better*, will be discussed later in this chapter.

Finally, it is necessary to comment on the phrase 'directed by irritations, sensations, volitions and associations', which is often misread by those unfamiliar with the rest of *Zoonomia*: they seize on 'directed by . . . volitions' and say 'ah! he implies desires can change the form'; but if so, why not sensations, etc., as well? The phrase becomes meaningless if misread in this way. The best way of seeing Darwin's intention is to add, after *associations*, the phrase '(which direct all human life)'. For Darwin was only indulging in a polite repetition of the thesis of the fourfold division of the sensorium, which runs right through *Zoonomia*: he probably inserted the reference at this prominent point because he felt uneasy that, during his exposition of evolution, he had not mentioned this thesis, which earlier in the book he alleges to be so important.

Darwin's rhetorical paragraph refers only to animals, but immediately afterwards he discusses insects, worms and vegetables, and concludes that they too undergo similar processes and arose from the same living filament.

Darwin expands his account of evolutionary development from microscopic life to man in his last poem, *The Temple of Nature*, which will be discussed in detail in Chapter VII. A few extracts from it are worth quoting now, however, because they usefully supplement *Zoonomia*.

In *The Temple of Nature* Darwin sums up the process of evolution in four brilliant couplets, emphasizing his belief that life began spontaneously in the sea:

> ORGANIC LIFE beneath the shoreless waves
> Was born and nurs'd in Ocean's pearly caves;
> First forms minute, unseen by spheric glass,
> Move on the mud, or pierce the watery mass;
> These, as successive generations bloom,
> New powers acquire, and larger limbs assume;
> Whence countless groups of vegetation spring,
> And breathing realms of fin, and feet, and wing.[15]

In a note on this passage, he points out that 'all quadrupeds and mankind in their embryon state are aquatic animals . . . the blood of the fetus becomes oxygenated from the passing stream of the maternal arterial blood; exactly as is done by the gills of fish from the stream of water, which they occasion to pass through them'. Thus every mammal relives in embryo the successive phases of evolution, from fish through amphibia to land animals:

> Cold gills aquatic form respiring lungs,
> And sounds aërial flow from slimy tongues.[16]

The analogy between evolutionary development and foetal growth was later elevated by Haeckel and others (apparently without acknowledgment of Darwin's priority) into the theory of recapitulation, which was once much respected but is now recognized as suffering from many flaws, despite its core of truth.[17]

Darwin was well aware of Nature's over-production in seeds and eggs, and the 'survival of the fittest'. He remarks in *The Botanic Garden*: 'Nature would seem to have been wonderfully prodigal in the seeds of vegetables, and the spawn of fish; almost any one plant, if all its seeds should grow to maturity, would in a few years alone people the terrestrial globe'.[18] Then, in the fourth canto of *The Temple of Nature*, he paints a vivid picture of the struggle for existence among animals, insects, plants and fish, emphasizing their interaction on each other. He begins with the animals:

> The wolf, escorted by his milk-drawn dam,
> Unknown to mercy, tears the guiltless lamb;
> The towering eagle, darting from above,
> Unfeeling rends the inoffensive dove;
> The lamb and dove on living nature feed,
> Crop the young herb, or crush the embryon seed.
> Nor spares the loud owl in her dusky flight,
> Smit with sweet notes, the minstrel of the night;
> Nor spares, enamoured of his radiant form,
> The hungry nightingale the glowing worm;
> Who with bright lamp alarms the midnight hour,
> Climbs the green stem, and slays the sleeping flower.

Then, after reminding us of some voracious insects, he turns to the vegetables:

> Yes! smiling Flora drives her armed car
> Through the thick ranks of vegetable war;
> Herb, shrub, and tree, with strong emotions rise
> For light and air, and battle in the skies;
> Whose roots diverging with opposing toil
> Contend below for moisture and for soil. . . .

Well may he conclude, after finding the sea no less cruel an environment:

> Air, earth, and ocean, to astonish'd day
> One scene of blood, one mighty tomb display!
> From Hunger's arm the shafts of Death are hurl'd,
> And one great Slaughter-house the warring world![19]

From the extracts already quoted from *Zoonomia* and *The Temple of Nature* we can see that Darwin (1) gave plenty of evidence to show that species do suffer change, (2) specified many of the factors which increase the chances of survival, such as special organs or protective adaptation, and (3) appreciated the process of natural selection. One question he does not answer: are the changes on which natural selection operates caused by the creature's own exertions or by chance mutations? Erasmus, like his grandson, assumed that both processes contributed, though orthodox modern theory allows only the second. It would be very unfair to expect Erasmus to have been more specific, however, for even now the question has not been finally answered, in that the word *chance* is a cloak for ignorance.

3

After 1794, statements of the principle of natural selection and theories of evolution come fairly thick and fast. It is not easy to say how many of them derived from *Zoonomia*; but a book popular enough to go through three editions in seven years is not likely to have been entirely unknown to subsequent theorizers on the same subject.

The first of the statements comes from the great geologist James Hutton (who was an acquaintance of Darwin). In his book *Principles of Agriculture*, which was left incomplete on his death in 1797 and not examined until 1947, Hutton wrote:

> In the infinite variation of the breed, that form best adapted to the exercise of those instinctive arts by which the species is to live, will be the most certainly continued in the propagation of this animal, and will be always tending more and more to perfect itself by the natural variation which is continually taking place.[20]

The next year, 1798, saw the publication of Malthus's *Essay on Population*, which has to be mentioned because Charles Darwin and Wallace both said it gave them the idea of the struggle for existence. Malthus propounded the view that human populations tend to grow in a geometric progression, whereas the means of subsistence, he thought, increase in an arithmetic progression. Since a geometric progression always overtakes an arithmetic one, population would always outgrow the means of subsistence, and Malthus concludes that there is no hope of attaining the high standard of living foreseen in Godwin's *Political Justice*, which his *Essay* was intended to refute. The mathematical clothing of Malthus's theory is in fact fraudulent,[21] and the kernel of truth in it had frequently been anticipated, for example by Joseph Townsend in his *Dissertation on the Poor Laws* (1786) and by Robert Wallace in his *Various Prospects of Mankind, Nature and Providence* (1761).[22]

Between 1800 and 1820 the French biologist Lamarck propounded his theory of evolution, primarily in the *Philosophie zoologique* (1809). He uses so many of the same arguments as Erasmus Darwin that he has often been suspected of plagiarism: 'by putting together various passages from Darwin's writings we can reconstruct, almost verbatim, the four principles of Lamarck'.[23] But the suspicion remains unproved. The chief difference between them is that for the mechanism of evolution Lamarck depends entirely on the wishes and needs of the animals rather than upon chance variations winnowed by natural selection, whereas Darwin propounded a judicious mixture of the two, as did his grandson Charles.[24] To put the difference at its crudest, Lamarck imagined the proto-giraffe adding an inch to his own stature by stretching up to eat high leaves, and then, as a result, having taller progeny. According to orthodox modern theory, based on natural selection, those proto-giraffes which happen to be taller than average because of small differences in their genes, will have a better chance of surviving, and their progeny will form a larger proportion of the next generation. Of these two contrasting pictures, only the second is now acceptable, because Lamarck relies on acquired characters being directly inherited, a process which Mendelian genetic theory in its present form does not allow. (There are, however, signs that this dogmatic denial will have to be modified now that the chemistry of the genes is being elucidated,[25] and the inheritance of acquired characters may yet, in some diluted form, become orthodox.)

The main point of interest here is that Lamarck developed the theory of evolution in more detail than Erasmus Darwin, but in doing so, set it on a wrong path which took many years to correct. To-day, we can see that Lamarck's evolutionary theory, though somewhat fallacious in its emphasis, should have served as a valuable step forward. Unfortunately, however, Lamarck's speculations in other subjects also incurred great odium in the biological world of the early nineteenth century, and he was severely criticized by Cuvier, the 'dictator of biology'. Lamarck's name was a millstone round the neck of the theory of evolution, and, combined with the Church's opposition to the idea, prevented it breaking surface more than momentarily until Charles Darwin came along with his mass of evidence.

Lamarck's theory was further developed, sometimes into fantastic forms, by Geoffroy Saint-Hilaire (1772–1844). His work, too, merely brought evolution into further disrepute.

Between 1810 and 1830 Lamarck's mistakes were combated by several British authors, who all denied that acquired characters could be transmitted: in the usual phrase, they believed heredity was hard, not soft, and they relied on the other of Erasmus Darwin's mechanisms, natural selection, rather than purposive or directive evolution.

The best known of these British expositors of natural selection, whose contribution was almost contemporary with Lamarck's, was the physician W. C. Wells (1757–1817). His paper on the subject was read before the Royal Society in April 1813, and published in 1818 in a new edition of his famous *Essay on Dew*. After remarking that negroes, and to a lesser extent mulattoes, remain immune from tropical diseases which are often fatal to whites, Wells points out that animals vary in some degree, and that these variations are exploited artificially by breeders. 'What is here done by art, seems to be done, with equal efficacy, though more slowly, by nature.' Of the accidental varieties of early man in Africa, 'one would be better fitted than the others to bear the diseases of the country. This race would consequently multiply' at the expense of its neighbours, until in the end the best-fitted race, which evidently happened to be black-skinned, would form the vast majority of the population.[26]

As Charles Darwin acknowledged, this account clearly describes the essentials of natural selection.

Evolutionary views were also propounded in 1813 by J. C. Prichard (1786–1848) in his *Researches into the Physical History of Mankind*, but in later editions of the book he became more cautious.[27]

A much more complete exposition, which, Darlington has argued,[28] is fuller, clearer and more correct than that of Charles Darwin forty years later, came in 1819 from W. Lawrence (1783–1867) in his book *Lectures on Physiology, Zoology and the Natural History of Man.* Lawrence made a grave tactical error, however: he applied his conclusions to man, and explained the degenerative effects of inbreeding in royal families and aristocracies, thus probably inspiring Peacock's Sir Oran Haut-Ton, the amiable Orang-Outan in *Melincourt.* Lawrence was attacked and repudiated with vigour by his medical seniors, the Church and the Government, which in the year of Peterloo was none too liberal, and Eldon the Lord Chancellor refused to allow copyright. To save his livelihood, Lawrence suppressed the book and channelled his talents into the strait and narrow path thereafter, ending as a baronet and Sergeant-Surgeon to Queen Victoria.

The next proponent of natural selection, who persuaded Charles Darwin to admit his priority,[29] was Patrick Mathew (1790?–1874). He expounded the principle in his book *On Naval Timber and Arboriculture* of 1831. Mathew, who was something of a curmudgeon in his later years, used to put on the title-pages of his books 'Discoverer of the principle of Natural Selection'. Mathew pointed out that Nature produced far more offspring than were needed 'to fill up the vacancies caused by senile decay'. Only the hardier individuals, or those better suited to their circumstances, 'struggle forward to maturity'; the weaker perish. 'This principle is in constant action, it regulates the colour, the figure, the capacities and instincts.'[30] Mathew, like Wells, knew and profited from the work of Erasmus Darwin.

After Mathew, the next notable evolutionist was Robert

Chambers, whose *Vestiges of the Natural History of Creation* was published anonymously in 1844. The book was condemned by almost every professional biologist (including Huxley and Charles Darwin) because of its factual errors, but these did not vitiate the book's lengthy account of evolution, which now seems perceptive and mostly correct.[31] And, whatever his deficiencies in knowledge, Chambers had an intuitive grasp of evolution in action, acquired perhaps through being born six-fingered and six-toed. Despite its rough handling by the reviewers, the book went through ten editions in nine years, partly because its author was rumoured to be Prince Albert. So it had a wide influence, and probably inspired the evolutionary verses about 'Nature, red in tooth and claw' in Tennyson's *In Memoriam* (1850), though, as we have seen, Erasmus Darwin had versified such views more fully and more forcibly fifty years earlier.

Even if the lay public took notice of *Vestiges of Creation*, the scientists didn't: evolution was no nearer acceptance in the 1850s than when Erasmus Darwin expounded it so completely, though Herbert Spencer restated the main principles cogently in 1852.

4

Erasmus's grandson Charles first became interested in the problem of species during his world-voyage as naturalist to H.M.S. *Beagle* (1831–6), and began his first notebook on the transmutation of species in 1837. He collected information on this topic at intervals for the next twenty years. Then, in June 1858, he received a short paper from A. R. Wallace, which anticipated in outline the views on evolution Darwin himself had arrived at, and had written down in unpublished essays in 1842 and 1844. In a compromise most creditable to all concerned, it was arranged that Wallace's paper and one by Darwin should be published simultaneously. They were, in 1858, and caused little stir, as might be expected, since they were quite short and similar to the essays and ideas of Wells, Lawrence, Mathew and the others, which had been equally ineffectual. At the end of 1858 the president of the Linnaean

Society said the year had not been marked by any striking discoveries.

It was the publication of *Origin of Species* in 1859 which turned the tide. Why? There were many reasons, closely linked and cumulative. First, despite its many confusions, it is among the greatest of scientific books, a masterpiece of patient exposition and argument. Second, Darwin was a well-known naturalist who rightly enjoyed a high reputation for his previous geological and biological work, especially that on coral reefs and barnacles. He was friendly with most of the leading geologists and biologists of the day, such as Hooker, Lyell, Huxley and Asa Gray, and had corresponded with them about variations in species. Third, most people were at last ready for evolution, though it needed the *Origin of Species* to make them realize it: the lay public had been prepared by *Vestiges of Creation*; while the biologists 'were experiencing . . . not the shock of discovery but of recognition'.[32] Fourth, Charles Darwin presented an overwhelming mass of relevant detail, which was the more unanswerable because the *Origin* was merely the abstract of a longer work. Fifth, he wisely omitted any mention of man, except in one cryptic sentence. Sixth, there was his complete honesty in stating the possible objections to the theory, which he had worried over for so long, and then answering them. This honesty brought its own reward: it proved to be a master-stroke which floored his critics. A strong group of professional scientists, with Huxley as the most militant, were soon convinced that Darwin was right. The main opposition came from a minority of biologists, such as Owen, and from orthodox Churchmen who felt that the 'argument from design' — the idea that God carefully created each species to fit with the others into an admirably integrated whole — could not be abandoned without fatally injuring Christianity. The opponents fought a strong rearguard action, but were defeated. To Charles Darwin, then, without a shadow of doubt, belongs the credit for convincing the world that the theory of evolution is true.

Usually, however, the scientist who originates an idea, or extends an existing idea and offers evidence in support, receives more credit than the one who finally convinces everyone that it must be true.[33] This is particularly obvious with those whose ideas were not known until after their deaths, like Copernicus or Mendel. Therefore, without wishing to detract from Charles Darwin's fine work on the subject, it is nevertheless surprising that he enjoys nearly all the fame, leaving little for Erasmus, who was the first to propound a satisfactory theory of evolution with evidence in support.

This paradox is usually resolved by the assertion that Erasmus held erroneous views; but, in fact, Charles Darwin's theory, as presented in its mature form in the later editions of the *Origin of Species*, is, in some important respects, less correct than that of Erasmus. Charles, like Erasmus, held that evolution occurred both through the accumulation of small fortuitous changes in form, as sifted by natural selection, and through Lamarckian-type changes resulting from 'the effects of use and disuse', as Charles phrased it. These Lamarckian-type changes can only occur if acquired characters are inherited; and Charles believed in such inheritance more strongly than Erasmus, as the following quotations (my italics) show. E. Darwin: '*many* of these acquired forms or propensities are transmitted to their posterity' (*Zoonomia*, I. 503). Lamarck: '*All* that has been acquired or altered in the organization of individuals during their life is preserved by generation'. C. Darwin: 'Perhaps the correct way of viewing the whole subject would be, to look at the inheritance of *every character whatever* as the rule, and non-inheritance as the anomaly' (*Origin of Species*, p. 26).

Charles Darwin was forced towards the erroneous Lamarckian camp for two reasons. First, it appeared in the 1860s that the geological time-scale was not long enough for the accumulation of small chance variations to be effective. Second, Darwin could not answer Jenkin's objection that solitary mutations would be 'blended back' towards the norm in the course of a few generations. As a result of these two retreats, the theory of evolution as presented in the last edition of the *Origin* was absurdly contradictory.[34] Erasmus Darwin, on the other hand, correctly assumed a time-scale of 'millions of ages', though it was not until radioactivity was discovered that the time-scale ordained by the late-Victorian physicists could be proved too short. Also, Erasmus, again correctly, believed that mutations often did not 'blend back' but were preserved; and he gave evidence to support this view.[35] Its truth, though known to Maupertius, was not provable until Mendelian genetic theory had been established early in the twentieth century. Erasmus was also far more aware of the religious and philosophical implications of evolution than his grandson. Finally, Erasmus comes nearer than Charles to the modern picture because he traced evolution back to its beginnings in spontaneously generated micro-organisms, a conclusion which, though now generally accepted, was too radical for Charles.[36]

Most historians of science seem to agree that Erasmus Darwin, Lamarck and Charles Darwin are the three greatest contributors to the theory of evolution. Of the three, Erasmus came nearest to the modern version of the theory, chiefly because he was the least committed to the hypothesis of the inheritance of acquired characters; and of course he preceded the other two. Erasmus Darwin had little hope of convincing the world, however, which in the 1790s was not ready for the theory of evolution; and, even if it had been, Erasmus's practical examples would not have been numerous and cogent enough, as Charles Darwin's were, to overcome opposition.

From the extracts quoted in this chapter, one can scarcely avoid the conclusion that Erasmus Darwin was the first to propound a well-rounded theory of evolution, with supporting evidence, though not enough of it for complete proof. Charles Darwin, with his habitual modesty, admitted, 'I pretend to no originality of idea . . . scarcely any novelty in my theory. . . . The whole subject of the book is its proof, its extension, its adaptation to classification and affinities. . . .'[37] When we remember this admission and the fact that Erasmus was rather nearer the modern theory than Charles, and when we also recall the tendency to honour the scientist who originates a theory rather than the one who finally proves it true, we may well conclude that the credit ought to be divided more equally between the two Darwins than has hitherto been customary.

This conclusion is reinforced by the astonishingly close links between their work: the Darwinian theory of evolution was a family affair. We have already noticed the tradition of paternal domination in the Darwin family down to Charles: Erasmus's father, though tender, kept his children in awe; Erasmus dominated his sons, of whom Robert adopted most of his father's ideas; and Charles's excessive dependence on his father (Robert) is remarked by all his biographers.[38] So, when his father advocated Erasmus's views on evolution, Charles could not fail to be impressed, as he admitted somewhat casually: 'It is probable that the hearing rather early in life such views maintained and praised may have favoured my upholding them under a different form in my *Origin of Species*'.[39] It is generally agreed that Charles Darwin's comments on the earlier evolutionists reveal his otherwise endearing character at its least attractive, and the disclaimer *under a different form* seems to be a gratuitous insult to his grandfather. As Darlington has put it, he 'damned Lamarck and also his grandfather for being very ill-dressed fellows at the same moment that he was engaged on stealing their clothes'.[40] With or without its disclaimer, however, Charles's statement is more revealing than he meant it to be, because to-day we tend to regard childish impressions as more indelible than the Victorians imagined. And Charles Darwin, remember, was famous for his retentive memory.

The same page of Charles's *Autobiography* offers further evidence on this topic: 'I had previously read the *Zoonomia* of my grandfather, in which similar views [on evolution] are maintained, but without producing any effect on me. . . . At this time [*c.* 1827] I greatly admired the *Zoonomia*. . . .'[39] Charles was obviously unconscious of his grandfather's influence: it was one of the virtues of his evolutionary work that he rethought the theory without conscious reference to his predecessors. But a book whose theories had been impressed upon him in youth and which he 'greatly admired' at the age of 18, must have influenced him strongly when he began developing those same theories for himself less than ten years later, even though he may have been unaware of it. When Charles had himself become convinced about evolution, he again read *Zoonomia* and was 'much disappointed, the proportion of speculation being so large to the facts given'.[39] From anyone less transparently honest than Charles Darwin, this remark would be classed as ungenerous, like that of the mathematician whose only comment after reading Newton's *Principia* was that he 'was disappointed that it was all done by geometry rather than calculus'. But, again because Charles was so honest, his statement becomes revealing, especially in its omissions. He did *not* say he was surprised to find the theory of evolution in *Zoonomia*: he already knew it was there. He did *not* say the evolutionary theory of *Zoonomia* was wrong: it isn't. In face of these tacit admissions, it is difficult to see why Charles Darwin did not give more credit to his grandfather, who is not mentioned in the first edition of the *Origin of Species*, and in later editions receives only a faint-hearted footnote, in the smallest print, stating that he 'anticipated the views and erroneous grounds of opinion of Lamarck'.[41] Since Charles Darwin's views were in these later editions of the *Origin* more Lamarckian than those of his grandfather, this remark takes on a barbed irony.

Charles's injustice to Erasmus — for it cannot be called less — was quite unintentional. Indeed, Charles interrupted his biological work in the 1870s to write what is still in many ways the best biography of Erasmus; and then, with characteristic modesty, he arranged for it to masquerade as an 'introduction' to an essay on Erasmus's scientific works, by Ernst Krause. In fact the 'introduction' is both longer and more valuable than the 'essay' it prefaced, a fact which is acknowledged in the title of the book, 'Life of Erasmus Darwin'. Yet 'E. Krause' is still credited with the authorship in most booklists and catalogues — a situation incongruous enough to arouse the unjust suspicion that Charles was atoning for injustice to his grandfather by being unjust to himself.

Why was Charles so unsympathetic towards Erasmus about the theory of evolution? Some of the reasons will always be hidden, but two are obvious. First, any scientist who revives a discredited theory advanced by his grandfather leaves himself open to ridicule: Bishop Wilberforce, in his influential essay-review of the *Origin of Species* in the *Quarterly Review*, made a long and most offensive comparison between Charles and his 'grandsire'.[42] To one so sensitive as Charles Darwin, such criticism was painful, and consequently he became over-anxious to appear to differ from Erasmus. Second, Charles had no sense of history.[43] By this I do not mean that he had no knowledge of history, but rather that, unlike Newton, he had no feeling of having 'stood on the shoulders of giants'; he built his own monument, ignoring the rougher but nearly identical edifice already erected by his predecessors. To Charles Darwin it was the factual content of the scientific work which mattered, not its date (or any link with his grandfather). This concern for essentials is admirable in its way, but some of its results were damaging, such as his many references to *my theory* in the first edition of the *Origin of Species*, most of which were gradually withdrawn in the fourth and later editions.[44] And, without a historical perspective, how can we avoid rating the modern science undergraduate higher than Newton, just because he knows more than Newton did about the physical world?

T. H. Huxley, who championed Charles Darwin so effectively, seems to have known little about the early evolutionists,[45] and the only person ready to attack Darwin for injustice to his predecessors was Samuel Butler, who made three other attacks simultaneously: he argued that Lamarck's version of evolution was better than Charles Darwin's; [46] he accused scientists in general and Darwin in particular of dishonesty; [47] and he insisted on the truth of his own ill-founded biological theories about memory.[48] These three latter attacks were vigorously and completely rebutted by

Darwin's champions (though Butler's theory of Unconscious Memory — he defined life as 'being possessed of a memory'[49] — was taken up in diluted form by Freud and Jung). Consequently, Butler was stigmatized as erroneous, and few seem to have noticed that the first of his four lines of attack was unanswered. It was assumed that he was altogether wrong, and the net result of his onslaught was to strengthen Charles Darwin's position as the founder of evolution, and to damage Erasmus Darwin by making him appear as extreme as Lamarck in his support of purposive evolution — a slander which has found its way into many histories of science. Yet Samuel Butler himself admitted that he was taking a liberty by including Erasmus in the band of purposive evolutionists,[50] and that Erasmus's views could be regarded as little different from those of his grandson.[51] It is more than time that Butler's mistaken labelling of Erasmus, well-intentioned but damning, should be finally erased.

Erasmus is often slandered over the word *Darwinizing*, coined by Coleridge, which, so it is usually said, was a derogatory phrase intended to mean *speculating wildly*. From an arch-speculator like Coleridge, however, such condemnation would be surprising; and the truth is that Coleridge was objecting to Darwin's evolutionary views, as his original words show: 'What! Did Sir Walter Raleigh believe that a male and female ounce (and, if so, why not two tigers and lions, etc.?) would have produced, in course of generations, a cat, or a cat a lion? This is Darwinizing with a vengeance.'[52] Coleridge, with his usual prophetic flair, was anticipating the Victorian religious objections to evolution. When we read of a Darwin being rebuked for his 'Orang Outang theology of the human race, substituted for the first chapters of the Book of Genesis',[53] it is not a Victorian bishop reviling Charles, but Coleridge castigating Erasmus fifty years before.

If Erasmus had a pervasive though unconscious influence over Charles, there should be plenty of parallels between *Zoonomia* and the *Origin of Species*. There are: almost every topic discussed in *Zoonomia*, and every example given, reappears in the *Origin*. To enumerate these parallels would take too much space, and still be inconclusive, since it could be argued that Erasmus and Charles were bound to discuss the same topics, even if they had worked quite independently; but one instance is worth quoting, the question of sexual selection. Charles's views on this subject, necessarily somewhat condensed, are as follows:

> This form of selection depends . . . on a struggle between the individuals of one sex, generally the males, for the possession of the other sex. . . . Generally, the most vigorous males, those which are best fitted for their places in nature, will leave most progeny. But in many cases victory depends not so much on general vigour, as on having special weapons, confined to the male sex. A hornless stag or spurless cock would have a poor chance of leaving numerous offspring . . . [other examples cited] . . . The war is, perhaps, severest between the males of polygamous animals, and these seem oftenest provided with special weapons. . . .[54]

Every point which Charles made here in the *Origin of Species* was to be found in Erasmus's analysis, which has been quoted on page 69, and, of the two, Erasmus is perhaps rather more cogent.

Two other similarities are worth remarking. First, the pages on evolution in *Zoonomia* abound in sentences of the form: 'When we consider example 1; when we compare X with Y; when we think over example 2; we cannot but conclude that . . .' And this is one of Charles Darwin's favourite ways of presenting his argument.[55] Second, there is the fine and famous *bravura* which concludes the *Origin of Species*:

> Thus from the war of nature, from famine and death, the most exalted object of which we are capable of conceiving, namely, the production of the higher animals, directly follows. There is a grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that whilst this planet has gone cycling according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and wonderful have been, and are being evolved.[56]

This is completely paralleled by Erasmus's rhetorical summary, quoted on page 71, and his references to the war in Nature, quoted on page 74.

Erasmus exercised his sway over Charles even more impressively by mapping out beforehand Charles's entire career as a biologist. Charles's 'first trial essay on the road to the *Origin* was called *Zoonomia*',[57] and thereafter nearly all Charles's books have their counterpart in either a chapter of *Zoonomia* or an essay-note to one of Erasmus's poems. Charles's three books on 'the species question', *The Origin of Species* (1859), *Variations of Animals and Plants under Domestication* (1868) and *The Descent of Man and Selection in Relation to Sex* (1871), find their parallel in section 39 of *Zoonomia* (Vol. I, pp. 478-533). Charles's geological interests, expressed in his books on *Coral Reefs* (1842) and *Volcanic Islands* (1844), were foreshadowed by Erasmus in notes to *The Botanic Garden* and *The Temple of Nature*.[58] Both the Darwins were fascinated by the fertilization processes of plants — 'nothing in my life has ever interested me more', said Charles: [59] thus *The Loves of the Plants* has as its progeny *Contrivances by which Orchids are Fertilized* (1862), *Cross- and Self-fertilization in the Vegetable Kingdom* (1876) and *Different Forms of Flowers on Plants* (1877). Both also welcomed signs of sense or sensibility in plants: Erasmus wrote *The Loves of the Plants*, while Charles remarked: 'It has always pleased me to exalt plants in the scale of organized beings'.[60] And his son Francis said of Charles, 'He could not help personifying natural things'.[61] Erasmus was delighted by insectivorous plants, including *Drosera*; [62] Charles told Lyell, 'I care more about *Drosera* than the origin of all the species in the world',[63] and wrote a famous book on *Insectivorous Plants* (1875). Charles's books on *Climbing Plants* (1875) and *Power of Movement in Plants* (1880) are foreshadowed in section 13 of *Zoonomia*, entitled 'Of vegetable animation', in section 8 of *Phytologia*, on 'The muscles, nerves and brain of vegetables' and in *The Loves of the Plants*.[64] Charles's book on *Expression of the Emotions in Man and Animals* (1872) develops yet another topic which interested Erasmus.[65] He also commented on the rise of soil levels resulting from animal and vegetable decay, and he liked worms;[66] so he would have been very much at home with Charles's *Formation of Vegetable Mould through the Action of Worms* (1881). Charles Darwin's first two books, on the voyage of the *Beagle*, inevitably offer plenty of parallels with Erasmus's interests; and he figures personally in Charles's two biographical books, the *Autobiography* and *Life of Erasmus Darwin*. So we are left with only one book by Charles which is not linked with Erasmus — the treatise on Cirripedia, which, although important to Charles's development, can be regarded as the 'odd man out' among his works.

An author can rarely foresee the subjects of his future books. To discover that his grandfather had it all charted in advance for him would be disconcerting, and the identical interests of the two Darwins, quite apart from their relevance to this chapter, create a firm link between them and offer a marvellous example of hereditary likeness.

Despite the unconscious rapport between the two Darwins, Charles persistently fails to note the similarity of his grandfather's interests, an omission which sometimes leaves him open to criticism. For example, one of the key topics in the *Origin of Species* is the geographical distribution of species and their means of dispersal, especially through seeds carried by ocean currents. 'Until I tried, with Mr. Berkeley's aid, a few experiments,' Charles remarks, 'it was not even known how far seeds could resist the injurious action of sea water.'[67] As a result of these experiments Charles tentatively concludes that it might be possible for seeds to germinate after floating across 900 miles of sea to another country. Yet in *The Loves of the Plants* he could have found details of *Cassia*, which grows in America and trusts her offspring seeds to the ocean:

> Soft breathes the gale, the current gently moves
> And bears to Norway's coasts her infant-loves.

And in a note Erasmus mentions other American fruits annually thrown on the coasts of Norway which 'are frequently in so recent a state as to vegetate, when properly taken care of'. Among them are 'the fruit of the anacardium, cashew-nut; of cucurbita lagenaria, bottlegourd; of the mimosa scandens, cocoons; of the piscidia erythrina, logwood tree; and cocoa-nuts'.[68] Where Charles sought to show seeds might possibly be carried 900 miles, Erasmus well knew species which were actually carried 3000 miles.

5

For Erasmus Darwin the theory of evolution was no mere scientific hypothesis but the very basis of his philosophy of life, as revealed in his last books, *Phytologia* and *The Temple of Nature*. The term 'philosophy of life' applies more truly to his outlook than to that of most thinkers, because he included all organic life in his world-view. The idea of evolution was deeply ingrained in his thinking for thirty years, and he saw more clearly than anyone else of his time the full horror of the struggle for existence, of the earth as 'one great slaughter-house'. But he also saw two hopeful patterns controlling and transcending the perpetual massacre. First, it was all in aid of evolution, through which species were steadily being *improved*: he saw it in terms of the survival of the fittest and the best; the process was cruel but the results were good. Second, he firmly believed that most creatures normally delight in life; their vascular actions are pleasurable. And the happier they are, the more likely it is that they are well adapted to their environment and hence will survive.[69]

This pleased Darwin, because he wanted organic life to enjoy the maximum of happiness: he extended the philosophy of Utilitarianism, then being developed by Bentham and others, to the animal and vegetable kingdoms, a philosophical *coup* as logical as it was bold. For, if all forms of life have a common microscopic ancestor, we should look on the animals and insects as our cousins —

man . . .
Should eye with tenderness all living forms,
His brother-emmets, and his sister-worms.[70]

The teeming millions doomed to die in the struggle for existence need not be mourned. While alive, an animal (or vegetable) contributes its mite to the *summum bonum*, the sum total of organic happiness. And when it dies, often because it has become incapable of further happiness, it gladdens the hearts of a myriad smaller creatures — especially those 'sister-worms' — so that the sum of happiness may be greater. 'Is not this a consoling idea to a mind of universal sympathy?' Darwin asks.[71] We can only answer, 'yes', with the proviso that few are lucky enough to share Darwin's own universality of mind.

At first sight Darwin's system may seem like carrying democracy to its uttermost logical conclusion, with every living organism having, as it were, a vote. But Darwin avoids this absurdity by recognizing that the more highly organized animals have a far greater capacity for happiness than their humbler brethren.

Darwin was so convinced of the crucial rôle of the struggle for existence that he would startle patients lacking in appetite with the warning 'Eat or be eaten'. And he used this maxim, which he called 'the first law of nature',[72] to justify his own heavy eating — a convenient irruption of theory into daily life.

Darwin's philosophy of life was wide enough to take in even geology, a subject on which his views were again ahead of his time, as we shall see in the next chapter. He was one of the earliest champions of Hutton's 'uniformitarian' theory of geology, propounded in 1788, which stood in opposition to the established catastrophic theory. Darwin thus believed that many rock-formations, such as limestone, chalk, coral and probably others, were the remains of marine animals —

> The marble mountain, and the sparry steep,
> Were built by myriad nations of the deep,—
> Age after age, who form'd their spiral shells,
> Their sea-fan gardens and their coral cells;[73]

while others, such as coal, derived from vegetables. So, for him, most mountains, formed from the skeletons of happy creatures,

> ARE MIGHTY MONUMENTS OF PAST DELIGHT.

As the capital letters proclaim, he set great store by this concept, and he was able to emphasize it further by adding the motto '*E conchis omnia*' to his family arms, which were, most conveniently, three scallop shells.

There may be differences of opinion as to whether Erasmus Darwin deserves the first, second or third place among evolutionists. But there can be no doubt that by his teleological twists he integrated the idea more thoroughly into his outlook on life than any other biologist who figures in the history of evolution. With his belief in the merits of evolution as such, he is the true, though often unrecognized, precursor of later evolutionary philosophies (which he might not have approved) such as those of Samuel Butler, Bergson, Bernard Shaw and Julian Huxley. Erasmus was also far more conscious than the other founders of evolutionary theory that it would upset contemporary religious belief. Charles Darwin, for example, was surprised to be condemned for omitting God from his picture of life,[74] whereas Erasmus knew he would give offence, and took pains to be tactful (see pages 71-2).

Sexual love is another topic illuminated by Darwin's idea of evolution. The earliest and the lowest forms of life were asexual. Sexuality, 'the chef-d'œuvre, the masterpiece of nature' as he calls it, was an improvement: with asexual reproduction 'the same species only are propagated ad infinitum; whereas by the sexual mode of reproduction a countless variety of animals are introduced into the world, and much pleasure is afforded to those which already exist in it'.[75] Thus, as a logical offshoot of his evolutionary theory, he concludes that sexual pleasure is an admirable thing, a conclusion which is also in harmony with his wish to promote organic happiness, to which sexual pleasure contributes. In its application to man his conclusion, though too socially disruptive to be fully applied, was, as it now seems, psychologically sounder than the Christian condemnation of sex. His approbation of sexual pleasure is pitched roughly halfway between the attitude of Shelley, who 'believed in love with an abstract fervour', and that of D. H. Lawrence, who believed in physical sexuality with equal fervour. Darwin's attitude is important for English literature because of his influence on Shelley (see Chapter VIII), and because he seems to have been the first English poet to treat sexual pleasure without any sense of guilt: his sixteenth- and seventeenth-century predecessors, even the most libertine of them, were unable to shake off their conditioning by Christianity. The one restraint which did baulk Darwin was the need to keep within the contemporary limits of decency: but he managed to expound his ideas under a thin veneer of decorum, and to include refrains like

And hail THE DEITIES OF SEXUAL LOVE,

because ostensibly he was referring to personified plants rather than humans. The title of his poem *The Loves of the Plants* was thus not so naïve as might at first appear.

6

To conclude this lengthy chapter it would perhaps be as well to recapitulate. We first traced the history of the idea of evolution, which was formulated by the Greeks yet remained only a hypothesis till the end of the eighteenth century. Erasmus Darwin showed the reality of evolution by many examples, and specified the essential mechanisms needed to initiate and control the process: first, the fact that some variations in species are inherited (those caused by gene mutations, as we should now put it); and, second, the crucial rôle of the 'survival of the fittest'. Lamarck, a few years later, developed the theory further, but in the wrong direction, implying that creatures changed to meet new needs, and passed on those changes to their descendants. Charles Darwin, fifty years later, redeveloped the theory, taking a slightly more Lamarckian position than Erasmus, and convinced the world that it was true by his mass of evidence. Although in several ways Charles did not come so near the modern version of the theory as Erasmus, their contributions are closely linked. Erasmus's views were impressed on Charles by his father, and Charles admired *Zoonomia* in his teens: so it would be natural for him unconsciously to use the same arguments when redeveloping the same theory; and that is just what happened. The link between Erasmus and Charles emerges most strikingly in Charles's books, all but one being foreshadowed by Erasmus.

Erasmus was far more aware than his successors of the philosophical and religious implications of evolution, and used the theory as the basis for his philosophy of organic happiness. We are all descended, he thought, from a common microscopic ancestor —

> Imperious man . . .
> Arose from rudiments of form and sense,
> An embryon point, or microscopic ens![76]

So we should look on even the humblest creatures as our cousins, and promote the general happiness of organic life. This community of feeling is unlikely to catch on, because it hits at man's self-esteem by implying that he is almost comparable with a corps of worms or a crop of wheat; but the philosophy is unshakeably logical and illuminates subjects as diverse as geology and sexual love. From microscopic ens arose sound philosophic sense.

NOTES TO V: THE THEORY OF EVOLUTION

Further abbreviations:
Eiseley=L. Eiseley, *Darwin's Century*. London, 1959.
Glass=B. Glass (ed.), *Forerunners of Darwin*. Baltimore, 1959.
Osborn=H. F. Osborn, *From the Greeks to Darwin*, 2nd ed. New York, 1929.

1. Apart from its military, mathematical and philosophical meanings, *evolution* had 3 biological meanings quite unconnected with changes in species, namely: (1) the unfolding of a flower; (2) the 'preformation' theory of embryonic development; and (3) the growth of an organism. See C. Singer, *Short History of Scientific Ideas*, pp. 500-3. Erasmus once referred to what we should now call 'special creation' as *sudden evolution* (*Zoonomia*, I. 509). Charles Darwin used the word in its modern sense in *The Descent of Man* (1871), but apparently did not use it in the *Origin of Species* (1859).
2. Aristotle, *Physics*, Bk. II, ch. viii (section 198b). The contorted wording of the Greek defies exact translation.
3. For Greek ideas on evolution, see Osborn, chap. 2.
4. See R. E. D. Clarke, *Darwin: before and after* (1958), p. 32.
5. See A. O. Lovejoy, in Glass, pp. 84-114, 173-206.

6. The contributions of Maupertuis, in his *Vénus physique* (1745), *Essai de Cosmologie* (1750) and *Système de la Nature* (1751), have been discussed by Glass, pp. 51-83. The two extracts cited here are from pages 58 and 77 of Glass's essay.

7. Darlington, p. 8.

8. *Zoonomia*, I. 490-1. See also *Phytologia*, p. 26.

9. *Economy of Vegetation*, I. 101, note.

10. *Loves of the Plants*, I. 375, note.

11. *The Temple of Nature*, Additional Note VIII, and I. 295-6.

12. See A. I. Oparin, *Life: its Nature, Origin and Development* (1961), chap. ii.

13. An *age* seems to mean roughly a *century*, as in 'The Victorian Age', etc. *Millions* is more difficult to interpret: *hundreds* means roughly 500, appreciably less than the next step up, a *thousand*. Since the next step above a million is presumably a billion, *millions* is more than 5 million — perhaps 10 million. If so, *millions of ages* is roughly 1000 million years.

14. See Eiseley, pp. 233-41.

15. *The Temple of Nature*, I. 295-302.

16. *The Temple of Nature*, I. 333-4.

17. See, *e.g.*, E. O. Dodson, *Evolution*, pp. 45-52.

18. *Economy of Vegetation*, IV. 355, note.

19. Quotations from *The Temple of Nature*, IV. 17-28, 41-6, 63-6.

20. E. Bailey, *Notes and Records of the Royal Society*, vol. 14, no. 1, pp. 126-7.

21. For the mathematical theory of population, see V. Volterra, *Theory of Functionals*, Dover edition (1959), pp. 19-25, 207.

22. See Eiseley, p. 123; and A. Wolf, *History of Science in the 18th Century*, p. 707.

23. Osborn, p. 222. See also S. Butler, *Evolution, Old and New*, pp. 258-60, and *More Letters of Charles Darwin* (1903), I. 125.

24. See, *e.g.*, the *cause célèbre* of the Madeira beetles, *Origin of Species*, p. 131.

25. See Sir Cyril Hinshelwood's farewell Presidential address to the Royal Society, Nov. 1960. *Proc. Roy. Soc.* A, **259**, 289-96. See also A. Durrant, *Heredity*, **17**, 26-61 (1962), and C. H. Waddington, *The Listener*, vol. 69, p. 121 (1963).

26. Quoted from Darlington, pp. 85-90.

27. See Darlington, p. 18.

28. See Darlington, pp. 19-22.

29. See G. de Beer, *Notes and Records of the Royal Society*, vol. 14, no. 1, p. 39.

30. Quoted from Darlington, pp. 90-1.

31. See A. O. Lovejoy, in Glass, pp. 356-414; and Osborn, pp. 312-16.

32. G. Himmelfarb, *Darwin and the Darwinian Revolution*, p. 370. Darwin himself disagreed with this view.

33. See W. I. B. Beveridge, *The Art of Scientific Investigation* (1961), p. 48.

34. See Eiseley, pp. 242-3. S. Butler, *Evolution, Old and New*, pp. 345-78, gives an acute (but Lamarckian) *exposé* of Darwin's confusions.

35. See p. 68; and *Phytologia*, pp. 117, 532.

36. The most Charles would say in the *Origin of Species* was, 'I believe that animals are descended from at most only four or five progenitors' (p. 458), though in the very last sentence of the book, which is strongly influenced by Erasmus, he does refer to 'a few forms or . . . one' (p. 463).

37. Quoted from G. Himmelfarb, *Darwin and the Darwinian Revolution*, p. 153.

38. See, *e.g.*, A. Keith, *Darwin Revalued*, p. 7; G. Wichler, *Charles Darwin* (1961), p. 154; R. Moore, *Charles Darwin*, pp. 35-6; F. Darwin, *Life and Letters of Charles Darwin*, I. 10-11.

39. C. Darwin, *Autobiography*, p. 49.

40. Darlington, p. 62.

41. *Origin of Species*, p. 8.

42. *Quarterly Review*, July 1860. S. Wilberforce, *Essays* (Murray, 1874), vol. I, pp. 89-91.

43. Cf. G. Himmelfarb, *Darwin and the Darwinian Revolution*, p. 143.

44. See S. Butler, *Luck, or Cunning?*, pp. 177-210.

45. See S. Butler, *Unconscious Memory*, pp. 10-11; Darlington, p. 35; K. Pearson, *Life of Galton*, II. 203.

46. S. Butler, *Evolution, Old and New*, *passim*; *Life and Habit*, chap. 13; *Luck, or Cunning?*, *passim*.

47. S. Butler, *Unconscious Memory*, pp. 38-51.

48. S. Butler, *Evolution, Old and New*, p. 37.

49. S. Butler, *Unconscious Memory*, p. 175.

50. S. Butler, *Evolution, Old and New*, p. 34; *Luck, or Cunning?*, pp. 79, 101-5.

51. S. Butler, *Luck, or Cunning?*, p. 157.

52. 'Notes on Stillingfleet' by S. T. Coleridge. *The Athenaeum*, No. 2474, p. 423 (1875).

53. Quoted by Nora Barlow in C. Darwin, *Autobiography*, p. 151.

54. *Origin of Species*, pp. 87-8. Charles later elaborated his views in *The Descent of Man* (1871).

55. See, *e.g.*, *Origin of Species*, pp. 38-9, 168, 391.

56. *Origin of Species*, p. 463.

57. Eiseley, p. 144.

58. Coral reefs: *Economy of Vegetation*, Note XVI and III. 90, note; *Temple of Nature*, II. 90, note. Volcanic islands: *Economy of Vegetation*, Note XXIV; *Temple of Nature*, I. 321-4 and Note III. The titles of Charles Darwin's books have been shortened in this paragraph.

59. *More Letters of Charles Darwin* (1903), II. 419.

60. C. Darwin, *Autobiography*, p. 135.

61. *Life and Letters of Charles Darwin*, I. 117.

62. See *Zoonomia*, I. 101; *Phytologia*, p. 133; *Loves of the Plants*, I. 231-42 and note, Additional Note (pp. 181-2) and I. 139, note.

63. A. Keith, *Darwin Revalued*, p. 103.

64. *Loves of the Plants*, III. 329, note; IV. 335, note.

65. See *Zoonomia*, I. 146-58 and section 34; *The Temple of Nature*, III. 434, note.

66. See *Phytologia*, pp. 242-3; *Economy of Vegetation*, IV. 456-60; *The Temple of Nature*, IV. 427-8.

67. *Origin of Species*, p. 355.

68. *Loves of the Plants*, III. 419-20, and III. 415, note. See also *Phytologia*, p. 113.

69. Charles Darwin also advocated both these ideas. See *Origin of Species*, p. 79 and pp. 116-17, 124-5, 462-3.

70. *The Temple of Nature*, IV. 427-8.

71. *Phytologia*, p. 558. Darwin expounds this philosophy best in *Phytologia*, pp. 556-60.

72. *Zoonomia*, II. 384; *Phytologia*, p. 556; *Female Education*, p. 61.

73. *The Temple of Nature*, IV. 431-4.

74. See *Origin of Species*, p. 455.

75. *Phytologia*, p. 103. This generalization is not always true. Some plants have thrived on asexual reproduction, relying on mutations to provide variety.

76. *The Temple of Nature*, I. 309, 313-14.

VI

THE BOTANIC GARDEN

As Nature lovely Science led
  Thro' all her flow'ry maze,
The volume she before her spread
  Of DARWIN's radiant lays.
WILLIAM HAYLEY

1

HIS long poem *The Botanic Garden* was the chief source of Darwin's national fame in his own lifetime: Part II, *The Loves of the Plants* (1789), was the public's favourite; but Part I, *The Economy of Vegetation* (dated 1791, though apparently not published till 1792 [1]), also enjoyed great success, reaching a fourth edition by 1799. The poem was at first universally overpraised, and Darwin was acclaimed by some as a greater poet than Milton.[2] The inevitable reaction, boosted by the parody *The Loves of the Triangles*, was no less excessive. *The Botanic Garden* became, and remained, a mere laughing-stock. As usual, the truth lies between the extremes. Darwin was not trying to rival Milton: he aimed to amuse and, if possible, to instruct; and he succeeded. *The Loves of the Plants* is in the lightest vein: we may laugh at it, but usually Darwin intended us to. It is, however, the instruction, mostly in *The Economy of Vegetation*, which now deserves more attention, and in reviewing the poem I shall dwell mainly on Darwin's far-sighted anticipations of modern developments in science and technology, ignoring other topics which, however important they seemed to him, are now dead issues. I shall not enumerate the poem's encyclopaedic contents in detail, relying on the extracts quoted to give a fair impression both of its flavour and of its substance.

In *The Botanic Garden* Darwin put into practice his unorthodox theory that poetry should consist largely of visual images. In the Interlude between Cantos I and II of *The Loves of the Plants* he writes:

> Poetry admits of but few words expressive of very abstracted ideas, whereas Prose abounds with them. And as our ideas derived from visible objects are more distinct than those derived from the objects of our other senses, the words expressive of these ideas belonging to vision make up the principal part of poetic language. That is, the Poet writes principally to the eye, the Prose-writer uses more abstracted terms.

Darwin can be applauded for striving to replace abstractions by sharp visual images, and he might seem to deserve a place beside Wordsworth and Coleridge, who were about to revolutionize English poetry by abandoning high-flown abstractions and artificial phraseology in favour of down-to-earth images and the real language of men. But, paradoxically, Darwin's poetry was just what Wordsworth and Coleridge were reacting against, because Darwin habitually generates his visual images by personifying an abstraction and then making this Person behave in a visually interesting way. Consequently actions performed by Abstractions are frequent in *The Botanic Garden*, and Darwin unintentionally flouts his own precepts. So, after pointing out the correct course for the stream of English poetry to follow, he himself swam into a backwater, which later dried up, leaving him exposed to our view like a stranded whale. There is life in him still, however, because the visual image remains a keystone of poetry and because he was, within his self-imposed limitations, a fine verse-technician: no one has ever excelled him in writing couplets crammed with scientific information which yet read easily and epigrammatically. He is eminently quotable.

The title of *The Botanic Garden* is deliberately misleading, being designed to attract genteel readers and lure them into a course of instruction in science and technology. Darwin admits in the Advertisement that he aims 'to inlist Imagination under the banner of Science; and to lead her votaries from the looser analogies, which dress out the imagery of poetry, to the stricter ones, which form the ratiocination of philosophy'. Part I of the poem is devoted mainly to physical science and technology; only near the end does botany peep in. The title of Part I, *The Economy of Vegetation*, is a complete misnomer, since there is little sign of vegetation and even less of verbal economy: Darwin enlarges upon and justifies his speculations in 115 quarto pages of 'Additional Notes'. The poem also has nearly 300 footnotes, anything between a line and a page in length. The second part of *The Botanic Garden* is shorter than the first, having 1,936 lines as against 2,448, and does live up to its title *The Loves of the Plants*, by showing how the various classes of plants are fertilized. But Darwin relieves the monotony of the Linnaean catalogue with what he calls 'The Poetic Exhibition', 180 word-pictures of subjects closely or loosely linked with the main theme. The subjects, which are listed at the end, range from 'Harlots' (twice) to 'St. Anthony preaching to fish', and from 'Arkwright's cotton mills' to 'Turkish lady in an undress'. The poem is also embellished with many plates, some by Fuseli and Blake.

2

The first two cantos of *The Economy of Vegetation* describe the Earth's origin and its physical features, with discourses on geology, chemistry and technology thrown in. Among the topics included are lightning, rainbows, fireballs, comets, steam-engines, volcanoes, earthquakes, limestone, porcelain, coal, morasses, mines, minerals, manure and many more. The third canto is aquatic, covering *inter alia* clouds, dew, rain, tides, rivers, canals, pumps and geysers. Canto IV starts in the same vein, with monsoons, fogs, barometers and submarines; and then at last we come to vegetation, with seeds, flowers and leaves—their anatomy and physiology. The poem is punctuated with anecdotes and mythological episodes more or less germane to the theme, and is alleged to be spoken by the Goddess of Botany to a meek audience of Sylphs, Gnomes and Nymphs: the tacit parallel with Pope's *Rape of the Lock*, which has a similar apparatus of sylphs, etc., re-emphasizes the poem's light-hearted basis.

One feature of Darwin's style which cannot be displayed in a small selection from this array of subjects, is his power of illuminating almost *any* subject with a pithy couplet or two, supported by an ingenious explanation or a speculation about future developments. He apologizes in the preface for making so many conjectures, but rightly points out that a flow of speculation is needed to stimulate confirmatory experiments.

Darwin begins his conjectures with cosmogony:

—'LET THERE BE LIGHT!' proclaim'd the ALMIGHTY LORD,
Astonish'd Chaos heard the potent word;—
Through all his realms the kindling Ether runs,
And the mass starts into a million suns;
Earths round each sun with quick explosions burst,
And second planets issue from the first;
Bend, as they journey with projectile force,
In bright ellipses their reluctant course. . . .
(I. 103-10)

Anna Seward remarks extravagantly that this passage is 'of excellence yet unequalled in its kind, and never to be excelled in the grandeur of its conceptions'.[3] Certainly it shows Darwin's talents to advantage: he turns the couplets so neatly that we accept as fine *bravura* what might seem mere bravado in bald prose; yet if we pause to reread the lines, we find plenty of information too. Darwin believes that, from a cloud of primeval gas, stars condensed and threw out planets, an idea which is among those still in vogue; and that these planets themselves ejected moons. Both planets and moons appear *bright* in the sun's rays, and move in *ellipses*, *reluctantly* because they would prefer to fly off at a tangent and are only constrained by gravity. He suggests there are perhaps a million other inhabited worlds (a hypothesis Shelley took over which is still acceptable to-day), but he slips in this heresy behind a conventional reference to 'the Almighty Lord'.

As the earth cooled, he believed, its nucleus solidified into a state of 'semi-vitreous fusion' and its vapours condensed to form the primeval ocean —

> When from its vaporous air, condensed by cold,
> Descending torrents into oceans roll'd.
> (II. 17-18)

Even now, however, the earth's interior is very hot:

> Where, in basaltic caves imprison'd deep,
> Reluctant fires in dread suspension sleep;
> Or sphere on sphere in widening waves expand,
> And glad with genial warmth the incumbent land.
> (I. 141-4)

He sees volcanoes as caused by water seeping down to the molten lava, and believes that whole seas once poured into the earth's interior. The ensuing convulsion ejected the moon from the earth, a theory later elevated into a consistent mathematical form by his great-grandson, Sir George Darwin.[4] The theory was generally accepted in 1900, but has since fallen out of favour; it has never been entirely disproved, however,[5] and, like so many astronomical conjectures, will probably be revived. When faced with an awesome event like the moon's birth, Darwin makes his speculations more plausible by bringing on the gnomes as witnesses:

> GNOMES! how you shriek'd! when through the troubled air
> Roar'd the fierce din of elemental war;
> When rose the continents, and sunk the main,
> And Earth's huge sphere exploding burst in twain. —
> GNOMES! how you gazed! when from her wounded side
> Where now the South-Sea heaves its waste of tide,
> Rose on swift wheels the MOON's refulgent car,
> Circling the solar orb, a sister-star,
> Dimpled with vales, with shining hills emboss'd,
> And roll'd round Earth her airless realms of frost.
> (II. 73-82)

After these cataclysms, earth-history was quieter, Darwin thinks, and the following short extracts from a long Note to *The Economy of Vegetation* summarize his views on geology, which are remarkably sound for an age when fallacious geological theories abounded:

> The masses or mountains of granite, porphery, basalt, and stones of similar structure, were a part of the original nucleus of the earth; or consist of volcanic productions since formed.
>
> On this nucleus of granite and basaltes, thus covered by the ocean, were formed the calcareous beds of limestone, marble, chalk, spar, from the exuviae of marine animals; with the flints, or chertz, which accompany them. And were stratified by their having been formed at different and very distant periods of time. . . .

(As we have seen in Chapter V, Darwin was particularly interested in the 'living rocks of worm-built coral' — his 'mighty monuments of past delight' in process of construction). His 'geological recapitulation' continues:

> Islands and continents were raised, consisting of granite or lava in some parts, and of limestone in others. . . . On some parts of these islands and continents of granite or limestone were gradually produced extensive morasses from the recrements of vegetables and of land animals; and from these morasses, heated by fermentation, were produced clay, marle, sandstone, coal, iron (with the bases of a variety of acids). . . .
>
> Subsequent earthquakes . . . have at different periods of time deranged the position of [the strata]. Hence the gravel, which was before in the beds of rivers, has in some places been raised into mountains. . . .
>
> (Additional Note XXIV)

In propounding these views Darwin utilized the theories of Buffon, Whitehurst and Hutton, but he is usually more correct than any of them, and particularly convincing on the subject of morasses, to which he devotes a lengthy note, giving details of a dying forest which rotted away and in fifty years was a peat-bog. Coal seams and oil he believed to be formed in a similar way, with the different seams deriving from forests in different eras; although coal measures may lie beneath marine deposits, they were not formed under the sea but only found themselves there as a result of later changes in level. Darwin justifies his belief that most rocks derive from organic remains (combined, of course, with existing minerals) with several detailed notes on

Flint, Coal, Clay, Production of calcareous earth, etc. Darwin's geological expositions, which almost constitute a treatise, since they run to about 15,000 words, serve as a preview of Lyell's *Principles of Geology* published forty years later, and stand out from among the erroneous catastrophic theories current at the time. Darwin's contribution to geology deserves more notice than it receives in the histories of science, though it does not stand as high as his work on evolution, because he owes a good deal to Hutton, who visited him at Lichfield about 1775.[6] Darwin is, however, more modern in outlook than Hutton, who is obsessed with the question of whether the excellent geological system he propounds shows signs of divine wisdom: 'with what wisdom is that destroying power disposed',[7] Hutton remarks, referring to erosion, which takes material from high mountains, where it is useless, and deposits it near shores to extend the land for man's benefit. Darwin wastes no time trying to prove that the processes of geology show wise power at work; instead he adopts the naturalistic modern approach. Darwin's geological theories have been neglected because he made the tactical error of scattering them among the notes to a poem, instead of writing a separate book on the subject.

The earth's outer coverings were no less fascinating to Darwin than its interior: the atmosphere was, for him, a happy hunting-ground, well-stocked with phenomena needing bold theories to explain them. He divides the atmosphere into three regions. The first, where clouds form, goes up to a height of 4 miles on his reckoning; it corresponds roughly to what we now call the troposphere. The second region is from 4 miles up to the height where the density falls to $\frac{1}{3000}$ of the sea-level value. This height he believed to be about 35 miles,[8] and he was right, though probably only by chance: for air density in the upper atmosphere is difficult to estimate, and even as recently as 1957 the accepted values at a height of 150 miles were 5 times too small.[9] Above 35 miles is the region

> Where lighter gases, circumfused on high,
> Form the vast concave of exterior sky,

and composed, he thought, of hydrogen. He was right (and for the right reasons) in thinking that hydrogen was the main constituent of the outermost atmosphere, or 'exosphere', though we now know hydrogen does not become dominant until much higher levels than he implied, probably about 2,000 miles. Nevertheless, his speculation was more accurate than orthodox scientific theory during most of the 150 years since his death. Jeans, for example, in developing his classical theory of the exosphere in 1925,[10] showed that if the exosphere were very hot, which it is, all the hydrogen would quickly escape from the earth; in fact, however, to counteract this loss, hydrogen is continually being generated from water vapour, high in the atmosphere, by the action of ultra-violet light, and also flows in from the solar atmosphere.[9]

Darwin goes on to discuss lightning, fireballs, shooting stars and the aurora, which in the eighteenth century were all thought to be purely terrestrial in origin and were called 'meteors'. (*Meteorology* originally referred to all transient phenomena in the Sphere of Air; it bridged the gap between Earth and Heaven.) The aurora Darwin rightly regards as electrical:

> Dart from the North on pale electric streams,
> Fringing Night's sable robe with transient beams.
> (I. 129-30)

Here he was only following accepted opinion, for the eighteenth-century electricians, as they were called, knew of the vacuum discharge tube and rightly connected its light with the aurora.[11] Darwin was, however, well ahead of his time in recognizing that the aurora belonged to the outermost layer of the atmosphere, above 35 miles. As usual, his views went unheeded by those who could have benefited: when the first International Polar Year was organized in 1882, the stations for simultaneous observation of the aurora were sited wrongly, because it was assumed that the aurora was only 5 miles high, and this mistake ruined the experiments.[12]

The discovery of the night airglow is usually attributed to Yntema in 1909;[13] but Darwin noted it, and explained correctly that it is due to the phosphorescent quality of almost all bodies, in a greater or less degree, which thus absorb light during the sun-shine, and continue to emit it again for some time afterwards.[14]

Darwin was not always right, however. He believed fireballs and shooting stars (whose height he gives correctly as about 60 miles) were atmospheric phenomena caused by hydrogen combining with oxygen — a plausible but wrong hypothesis. The idea that fireballs and shooting stars came from outer space was stubbornly opposed in the eighteenth century, even by the speculative Darwin. Yet the proof of it lay before him, unrecognized: for he gives the speed of these meteors (correctly) as about 30 miles per second, which greatly exceeds the speed for escape from the earth (7 miles per second), and hence demonstrates their extra-terrestrial origin.

On the subject of the lower atmosphere, meteorology in our sense of the word, Darwin is informative and generally right. His long discourses on clouds, winds and evaporation — when the 'Aquatic Nymphs'

lead with viewless march
The winged vapours up the aerial arch —

almost constitute a textbook of weather; and his nymphs and gnomes are continually taking to the air. He was a keen observer of weather, and devised a 'remote-control' weather-vane, which came down through the roof and actuated a pointer on the ceiling of his study, so that he could note the changes in wind-direction immediately. He thought sudden changes of wind were very significant, and seems to have recognized the existence of cold and warm fronts. Another of his proposals, which has since been put to use, is a weather-vane to rotate vertically as well as horizontally.

Darwin also seems to have been the first to explain how clouds form by the expansion and cooling of moist rising air, though Dalton (1793) is usually said to be the pioneer in this subject. In fact Dalton's explanations, in his *Meteorological Observations and Essays*,[15] are later and less complete than those of Darwin, whose work Dalton refers to. Darwin's account is in his paper 'Frigorific experiments on the mechanical expansion of air . . .', printed in the *Philosophical Transactions* of the Royal Society in 1788. He describes various experiments to show how air, on being allowed to expand freely into a region of lower pressure, 'by its expansion produces cold and devaporates'. (*Devaporate* is an old word worthy of revival, meaning 'condense into droplets'.) When a mass of air rises into a region of lower pressure, this process leads to the formation of clouds, and even, if it rises far enough, to ice crystals: 'When large districts of air from the lower parts of the atmosphere are raised 2 or 3 miles high, they become so much expanded by the great diminution of the pressure over them, and thence become so cold, that hail or snow is produced from the precipitated vapour, if they contain any'.[16] Darwin concludes this interesting paper by remarking what a great benefit it would be for 'produce and comfort' if human ingenuity could govern the winds, 'keeping the under currents from the S.W. and the upper currents from the N.E.',[16] a prospect which, nearly 200 years later, still seems remote.

Darwin's contributions to meteorology have received little recognition. His name does not appear among the 74 pioneers of meteorology listed by Napier Shaw,[17] though a poem attributed to him, entitled 'Signs of Rain', occupies the back cover of R. Inwards's standard book *Weather Lore*. His speculations on the upper atmosphere have also been neglected, though he gave correct values for the air density at great heights, and forecast correctly the composition of the exosphere and the height of the aurora, as well as discovering and explaining the airglow.

In *The Economy of Vegetation* Darwin touches on, and illuminates, many other scientific subjects, including electricity, chemistry, photosynthesis and solar physics. He also discusses geomagnetism, which he rightly conjectures is due to the earth's rotation. But we must now turn briefly to technology, which Darwin treats just as fully as science.

Darwin had been experimenting with steam engines even before he met Watt in 1767; the passage of years and the great commercial success of the Boulton-and-Watt engine confirmed his faith in its future:

> Soon shall thy arm, UNCONQUER'D STEAM! afar
> Drag the slow barge, or drive the rapid car;
> Or on wide-waving wings expanded bear
> The flying-chariot through the fields of air.
> — Fair crews triumphant, leaning from above,
> Shall wave their fluttering kerchiefs as they move;
> Or warrior-bands alarm the gaping crowd,
> And armies shrink beneath the shadowy cloud.
> (I. 289-96)

The only lapse in this series of prophecies is Darwin's failure to foresee that the steam engine would be too heavy for use in aircraft. But he repairs this flaw in a note: 'As the specific levity of air is too great for the support of great burthens by balloons, there seems no probable method of flying conveniently but by the power of steam, *or some other explosive material, which another half century may probably discover*' (my italics). In fact, nearly a whole century elapsed before the explosive-petrol engine became a reality and made air travel practicable. Darwin's prophecies about air transport quickly became, and have remained, the most famous in the poem, and they may have helped to inspire the inventor of the aeroplane, Sir George Cayley, who first became interested in mechanical flight in 1792, the year of the poem's publication, and quoted Darwin's prophecies in one of his papers on aerial navigation.[18]

Darwin also has plenty to say about balloons, with due reference to the early pioneers of flight, from Icarus to the Montgolfiers, and about submarines. He correctly foresaw the future importance of these 'diving balloons', and also paid a well-merited tribute to his 'sage' friend Priestley, whose discovery of oxygen from metal oxides showed how the crews might be supplied with breathable air:

> Led by the Sage, Lo! Britain's sons shall guide
> Huge SEA-BALLOONS beneath the tossing tide;
> The diving castles, roof'd with spheric glass,
> Ribb'd with strong oak, and barr'd with bolts of brass,

> Buoy'd with pure air shall endless tracks pursue,
> And PRIESTLEY's hand the vital flood renew.—
> Then shall BRITANNIA rule the wealthy realms,
> Which Ocean's wide insatiate wave o'erwhelms.
> (IV. 195-202)

Further technological topics expounded with equal verve are manure, sea defences, steel, pottery, marsh drainage, pumps and canals. This last subject is the cue for a tribute to another of his acquaintances, James Brindley, 'the unletter'd child' to whom the Aquatic Nymphs told all their 'secret spells':

> So with strong arm immortal BRINDLEY leads
> His long canals, and parts the velvet meads . . .
> (III. 329-30)

But we must now look at other features of the poem.

In accordance with his professed aims, Darwin relies chiefly on visual images; but a few abstract themes are allowed to intrude. The first and foremost of these is Love, which is displayed as admirable both in general —

> And Love and Beauty rule the willing world —

and in particular, as, for example, the love of Mars and Venus, whose unfortunate exposure when netted naked by Vulcan is detailed —

> Soft swells her panting bosom, as she turns,
> And her flush'd cheek with brighter blushes burns . . .
> (II. 175-6)

But Darwin is at his best with more unusual erotic escapades, as when he comically exploits electricity as an aphrodisiac in the kissing of an electrified Beauty:

> if on wax some fearless Beauty stand,
> And touch the sparkling rod with graceful hand;
> Through her fine limbs the mimic lightnings dart,
> And flames innocuous eddy round her heart;
> O'er her fair brow the kindling lustres glare,
> Blue rays diverging from the bristling hair;

While some fond Youth the kiss ethereal sips.
And soft fires issue from their meeting lips.
(I. 349-56)

Another topic which stirs Darwin to passion is the contrast between liberty and slavery. As we have already seen (p. 40), he welcomed the revival of liberty in the French Revolution, and he fiercely attacks slavery in both parts of *The Botanic Garden*, not forgetting to castigate the Church's equivocal attitude. (In 1783, for example, the Society for the Propagation of the Gospel refused to give Christian instruction to its slaves in Barbados.[19])

Heavens! on my sight what sanguine colours blaze!
Spain's deathless shame! the crimes of modern days!
When Avarice, shrouded in Religion's robe,
Sail'd to the West, and slaughter'd half the globe;
While Superstition, stalking by his side,
Mock'd the loud groans, and lap'd the bloody tide. . . .
The SLAVE, in chains, on supplicating knee,
Spreads his wide arms, and lifts his eyes to Thee;
With hunger pale, with wounds and toil oppress'd,
'ARE WE NOT BRETHREN?' sorrow choaks the rest.
(II. 413-18, 425-8)

Many of the classical myths retold in the poem are loose translations of Homer, and often, as Anna Seward pointed out, better than those of Cowper or Pope. Sustained poetic imagery is, however, rare in Darwin, because he anchors himself so firmly to actual objects. His nearest approach to consciously 'poetic' themes is in lines like these:

Roll on, YE STARS! exult in youthful prime,
Mark with bright curves the printless steps of Time;
Near and more near your beamy cars approach,
And lessening orbs on lessening orbs encroach;—
Flowers of the sky! ye too to age must yield,
Frail as your silken sisters of the field!
(IV. 367-72)

Even here, however, we are being informed of Herschel's theory that the stars are approaching each other and will finally coalesce.

This must end our sketchy sampling of *The Economy of Vegetation.* Darwin does also discuss vegetation, but that can best be taken in with *The Loves of the Plants*, to which we now pass.

3

The Economy of Vegetation is a wide-ranging survey of science and technology; *The Loves of the Plants* is a single-minded catalogue of vegetable sex-life, and Darwin's art cannot entirely conceal the repetitive tedium of his subject. He explains in his preface the system of Linnaeus, who divided the vegetable world into 24 classes, distinguished by the characters of the males in each flower. These classes were subdivided into 120 orders, often according to the number or form of the females; into 2,000 genera, usually distinguished by the form of the flowers or fruit; and 20,000 species, differentiated mainly by foliage. With drawings to help, Darwin then enumerates the classes, making appropriate English translations: Class 1, *Monandria*, one male, *i.e.* one stamen per flower; Class 2, *Diandria*, two stamens; and so on, down to Class 13, *Polyandria*, many males; then through other more complex systems such as Class 17, *Diadelphia*, two brotherhoods (with many stamens united into two companies), and Class 21, *Monoecia*, one house (with male and female in separate flowers, though on the same plant), down to *Cryptogamia*, clandestine marriage (plants whose flowers are not discernible).

Throughout the poem, Darwin uses his English equivalents for the Latin names: his aim is to replace the abstract scientific terms with human metaphors, and thereby to please readers who liked nothing better than a tale of lovers suing for a maiden's hand. In this he was eminently successful: as a result of his poem the 'average reader' of 1795 knew far more about plant classification than does his modern counterpart, and to-day, when science needs to be disseminated more widely, we must applaud Darwin for this feat. He emphasized in his introduction that the poem should not be taken too seriously: 'Gentle reader! Lo, here a CAMERA OBSCURA is presented to thy view, in which are lights and shades dancing on a whited canvas, and magnified into apparent life! . . . if thou art perfectly at leisure for such trivial amusement, walk in, and view the wonders of my INCHANTED GARDEN.' Ovid, he says, transmuted men and women into trees and flowers. 'I have undertaken by similar art to restore some of them to their original animality, after having remained prisoners so long in their respective vegetable mansions. . . .'

Rather surprisingly, Darwin does not refer to the book by his eldest brother Robert, *Principia Botanica*, published in 1787 (which, by a nice irony, was the centenary of Newton's *Principia Mathematica*). This admirable textbook provides, as its subtitle claims, 'a concise and easy introduction to the sexual botany of Linnaeus', and it shows the same passion for classifying as Volume II of *Zoonomia*. Although Erasmus himself was a great authority on the Linnaean system, there stands behind him, unmentioned except in a Note, the perhaps even more authoritative figure of the squire of Elston.[20]

To prepare the way for *The Loves of the Plants*, with its detailed examples, Darwin propounded the general principles of vegetable growth and reproduction in the last canto of *The Economy of Vegetation* and its Notes (which serve as a preview of the more detailed exposition in *Phytologia*). He particularly emphasizes the vital rôle of light in stimulating oxygen to escape from the leaves of plants and thereby to purify the atmosphere, and he imagines that the oxygen is enamoured of light. Darwin's ideas about vegetable reproduction, like his views on vegetable physiology in general (outlined in Chapter IV), are usually correct. But he did make one mistake. He failed to realize that the purpose of nectar in flowers is to encourage visits from insects which thereby become involuntary pollinators. Darwin admitted he was puzzled by nectar, and wrongly guessed that it might stimulate the pistils and stamens to activity. This error arose, paradoxically, because he was too successful with certain other speculations: for he seems to have been the first to explain correctly the working of protective devices in plants, such as prickles, poison, mimicry and viscous bands to deter climbing insects.[21] Elated at the success of these speculations, he assumed too hastily that plants never welcomed insects, and so shut his mind to the possibility that they welcomed bees. Though deceived by nectar, he well knew the rôles of anther and stigma, stamen and pistil, and he sums up the basic process of fertilization in some of his neatest verses:

While from on high the bursting *Anthers* trust
To the mild breezes their prolific dust;
Or bend in rapture o'er the central Fair,
Love out their hour, and leave their lives in air.
(IV. 453-6)

We have already seen how, in *Phytologia*, he argued that plants had a nerve centre and felt sensations; and how, among those sensations, he included the capacity for love. 'The vegetable passion of love', he says in a note to the verses quoted above, 'is agreeably seen in the flower of the parnassia, in which the males alternately approach and recede from the female, and in the flower of nigella, or devil in the bush, in which the tall females bend down to their dwarf husbands.'

This process is the one-track theme of *The Loves of the Plants*: with the aid of the Botanic Muse, Darwin amply fulfils his promise at the beginning of the poem to show the Sylphs and Gnomes

What Beaux and Beauties crowd the gaudy groves,
And woo and win their vegetable Loves.
(I. 9-10)

First comes *Canna*, or Indian reed, a virtuous flower with one male who unavoidably 'plights his nuptial vow' to the solitary female. With *Callitriche*, Stargrass, however, one male enjoys two females. In *Collinsonia*, on the other hand, two males woo one female, who obligingly satisfies them both (not to mention males in other flowers of the plant), while in *Iris*

three unjealous husbands wed the dame.

In *Lychnis* the males and females are on different plants, but each female saucily peeps out when mature:

> In gay undress displays her rival charms,
> And calls her wondering lovers to her arms.
> (I. 115-16)

In *Genista*

> *ten* fond brothers woo the haughty maid.

And so the list goes on.

Darwin exposes the love-life of ninety-six plants, and yet finds something different to say about each, because he gives each stamen and pistil traits or emotions appropriate to the form, colour, properties or habitat of the plant. Flax leads to a discourse on weaving. *Papyrus* is praised for making possible writing, with all its potentialities for knowledge. In *Trapa*, which grows half underwater, half above, the single female appears as a mermaid, with face and breasts above water, worshipped by four nereid forms. The vine (five males, one female) provokes an attack on the evils of alcohol:

> *Five* hapless swains with soft assuasive smiles
> The harlot meshes in her deathful toils;
> 'Drink deep', she carols, as she waves in air
> The mantling goblet, 'and forget your care'. . . .
> Fell Gout peeps grinning through the flimsy scene,
> And bloated Dropsy pants behind unseen. . . .
> (III. 361-4, 367-8)

Insectivorous and mobile plants fascinated Darwin most of all, because they behave almost like animals. Of the seven detailed drawings in the poem, two are of insect-catching plants and one of a climber. The pistils of *Silene*, catchfly, are seducers who lure innocent insects to their doom:

> Haste, glittering nations, tenants of the air,
> Oh, steer from hence your viewless course afar!
> If with soft words, sweet blushes, nods, and smiles,
> The *three* dread Syrens lure you to their toils,
> Limed by their art in vain you point your stings,
> In vain the efforts of your whirring wings! . . .
> (I. 143-

The sun-dew, *Drosera*, which Charles Darwin later investigated so thoroughly,[22] also impressed Erasmus:

> Queen of the marsh, imperial DROSERA treads
> Rush-fringed banks, and moss-embroider'd beds;
> Redundant folds of glossy silk surround
> Her slender waist, and trail upon the ground;
> *Five* sister-nymphs collect with graceful ease,
> Or spread the floating purple to the breeze;
> And *five* fair youths with duteous love comply
> With each soft mandate of her moving eye.
> (I. 231-8

In the moving plant *Hedysarum gyrans* the single female attracts her ten bashful suitors with movement and other arts:

> Loose wave her locks, disclosing, as they break,
> The rising bosom and averted cheek;
> Clasp'd round her ivory neck with studs of gold
> Flows her thin vest in many a gauzy fold;
> O'er her light limbs the dim transparence plays,
> And the fair form, it seems to hide, betrays.
> (IV. 339-44)

This, incidentally, is the 'poetic exhibit' which Darwin slyly catalogues as 'Turkish lady in an undress', though the connexion with Turkey is tenuous.

One can hardly read the poem's repeated relevations of plant polygamy, practised by pseudo-humans, without suspecting that Darwin was trying to subvert the custom of monogamy by implying that it was unusual in Nature. In celebrating the nuptials of *Adonis*, where 'many males and many females live together in the same flower', he craftily refers to the society of the Areoi in Tahiti, consisting of about 100 males and 100 females in promiscuous marriage:

> Thus where pleased VENUS, in the southern main,
> Sheds all her smiles on Otaheite's plain,
> Wide o'er the isle her silken net she draws,
> And the Loves laugh at all but Nature's laws.
> (IV. 487-90)

There are plenty of other extraneous erotic episodes, which in the 1790s were thought slightly shocking, and presumably helped to boost the sales. For example,

So shines the Nymph in beauty's blushing pride,
When Zephyr wafts her deep calash aside,
Tears with rude kiss her bosom's gauzy veil,
And flings the fluttering kerchief to the gale. . . .
(I. 339-42)

But most of the digressions which break the monotony of the catalogue are quite proper, drawing parallels between the behaviour of the flowers and that of actual or fabulous people, as in the lengthy and spirited tribute to Howard's philanthropy.

The most delightful of the digressions, however, are the comic ones. The *Menispermum*, Indian berry, for example, which is said to intoxicate fish, inspires a picture of St. Anthony preaching to the fishes:

'To Man's dull ear', He cry'd, 'I call in vain,
Hear me, ye scaly tenants of the main!'
(II. 249-50)

This time his call was certainly not in vain:

Torpedoes, Sharks, Rays, Porpus, Dolphins, pour
Their twinkling squadrons round the glittering shore;
With tangled fins, behind, huge Phocae glide,
And Whales and Grampi swell the distant tide.
(II. 253-6)

Then, as well he might at the sight of this gathering, the Saint cried 'Bless the Lord!' in a thundering voice:

The winds and waters caught the sacred word,
And mingling echoes shouted 'Bless the Lord!'
The listening shoals the quick contagion feel,
Pant on the floods, inebriate with their zeal,
Ope their wide jaws, and bow their slimy heads,
And dash with frantic fins their foamy beds.
(II. 261-6)

Since Darwin liked to poke fun at religion, we can safely assume that he intended this episode to be as ludicrous as it now seems. If so, are the many other lines for which he is ridiculed also premeditated foolery? Some of them obviously are, such as the kissing of the electrified beauty or the nymphs taking a tea-break, when the Naiad-in-charge, he tells us,

> Culls the green herb of China's envy'd bowers,
> In gaudy cups the steamy treasure pours;
> And, sweetly smiling, on her bended knee
> Presents the fragrant quintessence of Tea.
>
> (II. 481-4)

We can never be sure when Darwin is laughing at us for thinking his comedy unintentional: for we have to remember that he was no pallid poetaster, like Bunthorne in *Patience*, but a full-blooded man of the world, famous for his wit and strongest in the departments of irony and sarcasm. He was a real connoisseur of irony, which, he suggested, deserved a special punctuation mark, such as an inverted exclamation mark, for the benefit of readers weak in irony.[23] This sly form of humour specially appealed to him, and it may be that he has the last laugh over the solemn critics who have ridiculed him. Certainly, much of the poem is only meant to be 'light and frolic', as Anna Seward recognized, like his playful letter to Miss Pussey and the nonsense verses quoted in Chapter III. Bernard Blackstone has suggested that Darwin's 'grotesquerie of diction . . . may be directed towards an effect: and if that effect is memorableness, the aim is magnificently successful'.[24] And J. V. Logan, one of the very few critics to study Darwin's verse carefully, maintained that *The Loves of the Plants* was 'the culmination of Darwin's humour . . . the fine flowering of Darwin's bent to write light and humorous verse': [25] these judgments should not lightly be set aside by those whose acquaintance with Darwin is more superficial.

4

There are several reasons for the immediate success of *The Botanic Garden*. First, it exploited the vogue for botany which existed among the genteel poetry-buying society of the time. Second, the versifying of discoveries in science was a novel technique. There is no previous English poem at all like it:[26] the nearest parallel is Lucretius's *De Rerum Natura*. Third, the versifying was brilliant: as J. V. Logan has remarked, Darwin was something of a genius with the couplet, 'composing with impeccable correctness of rhythm and rime, yet sensitive to melodic nuances'.[26] Fourth, the continual wooings and the erotic scenes in *The Loves of the Plants* appealed to the wide public who read romances in quantity, and liked something a little naughty. Darwin well knew this, for even Linnaeus had been censured for his 'lewd method' of sexual classification;[27] and in his Commonplace Book Darwin notes that Linnaeus might be translated 'without losing his sexual terms . . . and yet avoiding any indecent idea'.[28] Fifth, it was shrewd tactics to publish the lighter *Loves of the Plants* first, and let the more substantial *Economy of Vegetation* follow in its wake.

The professional literary men enjoyed *The Botanic Garden* just as much as the general public. Cowper composed a poem in its honour —

> We, therefore, pleas'd, extol thy song,
> Though various, yet complete,
> Rich in embellishment, as strong,
> And learn'd, as it is sweet. . . .[29]

Horace Walpole, usually sparing of his praise, wrote: 'the twelve verses that by miracle describe and comprehend the creation of the universe out of chaos, are in my opinion the most sublime passage in any author, or in any of the few languages with which I am acquainted. There are a thousand other verses most charming, or indeed all are so, crowded with most poetic imagery, gorgeous epithets and style. . . .[1] Dr. Darwin has destroyed my admiration for any poetry but his own.'[30] Even Mrs. SchimmelPenninck, who heartily disliked Darwin, remembered the great pleasure the poem gave her family, an impression which, 'though at the distance of sixty years, I shall never forget'.[31] The poem was also admired by many scientists and engineers: Telford called it 'a very wonderful and masterly performance'[32] and, like Dr. Beddoes, tried writing similar poems himself; James Keir was equally appreciative and reported that 'I have had the pleasure of making [Mrs. Blair] forget a violent toothache by reading part of your poem to her'.[33] Though Darwin was to be attacked and parodied later in the 1790s, on political and religious grounds, the initial success of his poem was as complete as any author could wish.

The lengthiest and most searching criticism of the poem was by Anna Seward, who devoted 216 pages of her *Memoirs of Dr. Darwin* to the topic. Though inevitably bound by the assumptions of her Age, Anna is acute as a close critic and by no means wholly favourable to Darwin. She justly remarks that 'Dr. Darwin's poetry, while it delights the imagination, leaves the nerves at rest'. She thinks his picture of a town on fire much better than Dryden's in *Annus Mirabilis*, but she complains that he carries personification too far in making the virgin air love nitrogen, and treating fire as a rival. She also remarks acidly of the St. Anthony episode that 'its language violates the third commandment deplorably'. She is not generally censorious about Darwin's rather warm sexual pictures: for, though she condemns the netting of Mars and Venus as 'voluptuous', the 'floral harems' do not worry her, because they are based on fact; and Venus wringing her hair as she stands naked after emerging from the sea merely draws the two comments, 'no position can be more favourable to female symmetry' and 'no author ever had a mind more keenly awakened to grace in all its varieties'. Despite her objections, Anna concludes that *The Botanic Garden* is 'one of the richest effusions of the poetic mind, that has shed lustre over Europe in the eighteenth century'.[34]

Though we may not entirely agree with her, we have to admit that Darwin's success in creating a best-selling poem out of scientific subject-matter remains unique in the history of English poetry. As L. T. C. Rolt has remarked, he achieved 'the astonishing feat of rendering in imaginative terms which any literate man could then appreciate the sum of human knowledge at that time. It was an achievement which was never repeated or even attempted.'[32]

NOTES TO VI: *THE BOTANIC GARDEN*

1. H. Walpole, *Letters* (ed. Mrs. Paget Toynbee; Oxford, 1905), XV. 110.
2. See Coleridge, *Letters*, II. 738.
3. Seward, p. 193.
4. For a non-technical account, see G. H. Darwin, *The Tides* (1898), pp. 249-56.
5. See, *e.g.*, E. Öpik, *The Oscillating Universe* (1960), pp. 29-32.
6. See C. Hutton *et al.*, *Philosophical Transactions, abridged*, vol. 16, p. 373.
7. J. Hutton, *Theory of the Earth* (Edinburgh, 1795), II. 387. See also I. 3-18, II. 548-60.
8. *Economy of Vegetation*, I. 126, note.
9. D. King-Hele, *Satellites and Scientific Research* (2nd ed., 1962), pp. 113-14, 188-90.
10. J. H. Jeans, *Dynamical Theory of Gases* (4th ed., 1925), pp. 337-48.
11. See J. Priestley, *The History and present State of Electricity* (1767), pp. 298-9, 376.
12. See J. T. Wilson, *IGY*, *The Year of the New Moons* (1961), p. 28.
13. See J. W. Chamberlain, *Physics of the Aurora and Airglow* (1961), p. 347.
14. *Loves of the Plants*, IV. 45, note. See also *Economy of Vegetation*, I. 177, note.
15. J. Dalton, *Meteorological Observations and Essays*, (2nd ed., Manchester, 1834), pp. 125-32.
16. C. Hutton *et al.*, *Philosophical Transactions, abridged*, vol. 16, pp. 372-7.
17. Napier Shaw, *Meteorology in History* (1926), pp. 118-45.
18. See J. L. Pritchard, *Sir George Cayley* (1961), pp. 233, 93.
19. W. Lecky, *History of England in the 18th century* (1892), II. 249.
20. See Nora Barlow, 'Darwin as a Botanist', pp. 14-15, in *A Darwin Centenary* (1961).
21. See E. Krause, pp. 158-9 in C. Darwin's *Life of E. Darwin.*
22. C. Darwin, *Insectivorous Plants* (1875), pp. 1-285.
23. See J. E. Stock, *Life of Thomas Beddoes*, p. 119.
24. B. Blackstone, *The Consecrated Urn*, p. 13.
25. Logan, p. 99.
26. See Logan, pp. 120-42.
27. See '*C. Linnaeus: Species Plantarum*', *facsimile of first edition* (Ray Society, London, 1957), I. 25.
28. Commonplace Book, p. 72.
29. Cowper, *Poetical Works* (O.U.P., 1911), p. 418.
30. H. Walpole, *Letters*, XV. 41.
31. SchimmelPenninck, I. 243.
32. L. T. C. Rolt, *Thomas Telford* (1958), p. 29.
33. J. K. Moilliet, *Life of Keir*, p. 81.
34. Quotations from Seward, pp. 174, 321, 245-6, 378-9.

VII

THE TEMPLE OF NATURE

> In the mud of the Cambrian main
> Did our earliest ancestor dive:
> From a shapeless albuminous grain
> We mortals our being derive.
> GRANT ALLEN, *Ballade of Evolution*

DARWIN's last poem, *The Temple of Nature*, or *The Origin of Society*, is largely devoted to stating his evolutionary view of life. He follows the progress of life from its origin as microscopic specks in primeval seas to its present culmination in a civilized human society. The ideas propounded and argued in *Zoonomia* are presented as if they were historical facts, though Darwin admits in his preface that his aim 'is simply to amuse by bringing distinctly to the imagination the beautiful and sublime images of the operations of Nature in the order, as the Author believes, in which the progressive course of time presented them'. If the author's beliefs had been wrong, the poem would be a mere curiosity to-day; but since he was usually right, *The Temple of Nature* acquires a prestige which prevents us judging it by its literary merit alone. It is a splendid achievement, at a time when biological science was by modern standards so primitive, to have described the origin and development of life in a way which is still largely acceptable. As literature, too, *The Temple of Nature* outshines *The Botanic Garden*, because the couplets are just as polished, and the chronological theme provides a coherent structure, which its predecessor lacked.

The Temple of Nature, like *The Economy of Vegetation*, is in four cantos, carries a heavy cargo of notes and runs to about

2,000 lines (1,928, to be exact). The first canto shows life's origin and its evolution from aquatic to land forms. The second deals with reproduction — asexual, hermaphroditic and finally sexual reproduction with all its advantages. The third canto traces the progress of the mind, from its origin as a mere meeting-place of nerves to its present complexity in man. In the fourth canto, 'Of Good and Evil', Darwin first describes the struggle for existence and the survival of the fittest, and then dwells on the pleasures of life and outlines his philosophy of organic happiness.

Canto I begins dauntingly, as Darwin invokes the generalized personifications, Nature, Love, Oblivion, etc., which preside over the poem, and describes the Temple of Nature, whose priestess, Urania, is to expound Nature's mysteries, ostensibly for the benefit of a virgin band of initiates. Fortunately the burden of allegory is relieved, both here and later in the poem, by lighter touches, including some lines to which time has given a comic twist. Every passenger on British Railways, knowing those gay posters of holiday resorts optimistically sunlit, will misread Darwin's

Bright scenes of bliss in trains suggested.

And on reaching the seaside what do we see? Darwin has the answer:

In slight undress recumbent Beauties rest.

Had Darwin really known the beaches would be beautified by girls in bikinis recumbent in sun-worship, he could scarcely have improved his wording; and we laugh at him for posthumously hitting such a trivial nail on the head. Comedy aside, the purpose of the first 200 lines is to set the scene for the rest of the poem, which consists mainly of monologues either by the Muse or by Urania, who is also called the Priestess of Nature, the Hierophant, and sometimes just 'the Nymph'.

After the abstract introduction we come down not perhaps to brass tacks, but at least to microscopic specks, and learn how,

> Nurs'd by warm sun-beams in primeval caves,
> Organic Life began beneath the waves.
>
> (I. 233-4)

It happened, Darwin surmises, by chance chemical actions, with the stimulus of sunlight to provide the energy.

> Hence without parent by spontaneous birth
> Rise the first specks of animated earth;
> From Nature's womb the plant or insect swims,
> And buds or breathes, with microscopic limbs.
>
> (I. 247-50)

In a long note on spontaneous generation Darwin contends that many of the micro-organisms associated with disease are also spontaneously generated, an error which prevented him discovering the germ theory of disease, but does not invalidate his picture of the origin of life, since spontaneous generation is possible in a favourable sterile environment.[1] He believes that the primeval microscopic creatures gradually evolved into more complex forms, until they finally developed leaves, lungs or gills. The next step in evolution, as he sees it, is the growth of sensation, which 'cannot exist till the nerves are united in the brain':

> Next the long nerves unite their silver train,
> And young SENSATION permeates the brain.
>
> (I. 269-70)

And after sensation come volition and association. There follows the brilliant summary of evolution,

> ORGANIC LIFE beneath the shoreless waves
> Was born and nurs'd in Ocean's pearly caves;
> First forms minute, unseen by spheric glass,
> Move on the mud, or pierce the watery mass;
> These, as successive generations bloom,
> New powers acquire, and larger limbs assume;
> Whence countless groups of vegetation spring,
> And breathing realms of fin, and feet, and wing.
>
> (I. 295-302)

As land rises, he envisages the microscopic sea-creatures being cast ashore, and the larger ones going ashore to forage, with some gradually adapting themselves to a land existence 'by innumerable successive reproductions for some thousands, or perhaps millions of ages', after which they 'may at length have produced many of the vegetable and animal inhabitants which now people the earth' (I. 327, note). The transformation from gills to lungs he illustrates by references to the plant *Trapa*, which grows in water and air, to tadpoles and their transformations, to mosquitoes, to fishes which have both lungs and gills, and others. In a note on amphibians he discusses, admirably, how the heart mechanisms of quadrupeds change at birth, when they go from an aquatic to an air-breathing life — a process he also describes in verse:

> Thus in the womb the nascent infant laves
> Its natant form in the circumfluent waves;
> With perforated heart unbreathing swims,
> Awakes and stretches all its recent limbs;
> With gills placental seeks the arterial flood,
> And drinks pure ether from its Mother's blood.
> Erewhile the landed Stranger bursts his way,
> From the warm wave emerging into day;
> Feels the chill blast, and piercing light, and tries
> His tender lungs, and rolls his dazzled eyes.
> (I. 389-98)

Rathke's discovery of gill slits in mammal embryos was not made until the 1820s[2]; so Darwin's mention of gills is yet another correct speculation. Then, as if to show he is at home with generalities as well as detail, he notes how amphibious embryos help to explain such myths as Venus rising from the sea.

Darwin also reiterates his view that the remains of lowly creatures, especially the shelly ones, both in the sea and on land, have built the huge calcareous rock deposits:

> Now in vast shoals beneath the brineless tide,
> On earth's firm crust testaceous tribes reside;
> Age after age expands the peopled plain,
> The tenants perish, but their cells remain;

Whence coral walls and sparry hills ascend
From pole to pole, and round the line extend.
(I. 315-20)

In a note on *brineless tide* he contends that the salt of the sea has gradually been accumulating as rivers bring down dissolved salts. Originally the sea was fresh, he says, a view which subsequently won wide acceptance.

In Canto II, which deals with reproduction, Darwin begins characteristically by touching on the fundamental questions. We do not know the reasons for ageing, he says, and speculates that the period of youth and vigour might be indefinitely extended. Also, he points out, 'before mankind introduced civil society, old age did not exist . . . as all living creatures, as soon as they became too feeble to defend themselves, were slain and eaten by others . . .' (II. 3, note). Ageing can at present only be conquered by reproduction, whose various forms he then considers. First in time came the asexual form:

The Reproductions of the living Ens
From sires to sons, unknown to sex, commence. . . .
Birth after birth the line unchanging runs,
And fathers live transmitted in their sons.
(II. 63-4, 107-8)

Examples are the 'lone truffle', polypus and tapeworm. The second stage, Darwin believed, was that of hermaphrodites, which had the qualities of both sexes and could impregnate themselves or each other. In support of this idea he notes that many vegetables are still hermaphroditic, and some animals, such as snails and worms; while even quadrupeds have residual hermaphroditic traits, such as the nipples on males. The third stage, reached by some plants and the majority of animals, was sexual reproduction, the masterpiece of nature, which allows the mixing of characters from both parents and is the key to evolutionary improvement (see page 92). Cupid and Psyche therefore deserve the highest honour among the Greek gods:

Behold, he cries, Earth! Ocean! Air above,
And hail the DEITIES OF SEXUAL LOVE!

> All forms of Life shall this fond Pair delight,
> And sex to sex the willing world unite. . . .
> (II. 243-6)

They also merit our thanks because they

> Fill Pleasure's chalice unalloy'd with pain.

As in *The Loves of the Plants*, Darwin extends the concept of sexual pleasure to vegetables:

> Hence on green leaves the sexual Pleasures dwell . . .
> (II. 263)

Darwin notes that some creatures utilize more than one of the methods of reproduction. The aphis, for example, goes through many fortnightly asexual generations in summer and then reverts to sexual reproduction in autumn, laying eggs for hatching next spring:

> Unmarried Aphides prolific prove
> For nine successions uninform'd of love;
> New sexes next with softer passions spring,
> Breathe the fond vow, and woo with quivering wing.
> (II. 131-4)

He also has much to say about hereditary diseases. In asexual creatures these usually prove fatal:

> The feeble births acquired diseases chase,
> Till Death extinguish the degenerate race.
> (II. 165-6)

Thus, ingrafted apple trees gradually lose vigour

> till, amended by connubial powers,
> Rise seedling progenies from sexual flowers.
> (II. 175-6)

Hereditary diseases are mitigated but not eliminated by sexual reproduction. In man, gout, insanity and consumption are to some extent hereditary, he thinks, but such disease is less likely with 'marriages . . . into different families than . . . into the same family'. He ends his long note on hereditary diseases with the acute observation: 'As many families become gradually extinct by hereditary diseases, as by scrofula, consumption, epilepsy, mania, it is often hazardous to marry an heiress, as she is not unfrequently the last of a diseased family'. (Additional Note XI.) This injunction against marrying heiresses was reformulated in a less satisfactory form, and confirmed statistically, by Sir Francis Galton in his book *Hereditary Genius*.[3] It seems to have been a characteristic of Darwin's grandsons that from time to time they unconsciously reproduced and verified some of his bright ideas.

Although sexual reproduction is so much superior to other forms, the pleasure it gives has a darker side, in the rivalry between males. Darwin versifies the paragraph from *Zoonomia* about the battles among cocks, boars and stags (see page 69), and cites Helen of Troy too in support of his thesis. He then offers some rather comic pictures of connubial bliss in animals:

> The Lion-King forgets his savage pride,
> And courts with playful paws his tawny bride;
> The listening Tiger hears with kindling flame
> The love-lorn night-call of his brinded dame.
> Despotic LOVE dissolves the bestial war. . . .
> (II. 357-61)

All birds, beasts, insects, fish and plants then combine to

hail THE DEITIES OF SEXUAL LOVE.

In the third canto, on the progress of the mind, Darwin reviews the achievements of man. Sometimes he covers the same ground as in *The Economy of Vegetation* or *Zoonomia*, and we need not follow him, except to note how well he versifies the new discoveries in chemistry and electricity. For example, there is his pleasing picture of the atmosphere and oceans:

> Or mark how Oxygen with Azote-Gas
> Plays round the globe in one aërial mass,
> Or fused with Hydrogen in ceaseless flow
> Forms the wide waves, which foam and roll below.
> (III. 13-16)

The mind progresses, Darwin believes, by a process of imitation. Art begins with the imitation of Nature, an imitation which the mind slightly modifies. His theory seems to be that art is about 95 per cent imitation and 5 per cent inspiration, with the inspiration itself arising as a kind of bonus from assiduous imitation. Language began, he believes, with the 'dumb gestures' of miming, which are imitations of real movements, and, though man now communicates by 'quick concussions of elastic air', language is still learnt by imitation. Also, if animals or men are to form coherent social groups, they must observe certain customs, which can be regarded as imitation *par excellence.* Darwin covers all these topics and many more — perception, beauty, man's advantage in possessing hands, the organization of the insect world, the struggle for existence, sublime scenery and, finally, sympathy, that seraph who 'charms the world with universal love'.

One of his most detailed discourses is on language. In one long and pedantic note he propounds a theory of language, arguing that words fall into four classes: conjunctions and prepositions; nouns; adjectives, adverbs, etc.; and verbs. In another and more interesting note, he analyses articulate sound. He explains the scientific basis of sound, deplores the inadequacy of the alphabet and then lists and discusses the thirty-one sounds into which English speech can, he thinks, be subdivided. It is a convincing and thorough analysis, and gives the lie to those who accuse him of always being speculative and sketchy. He was the more confident of his ground because he had as a student been proficient in Gurney's system of shorthand — indeed some specimens of his shorthand appeared in Gurney's manual on the subject[4] — and he later tried to improve the system and also constructed a speaking-machine, which will be described in Chapter IX. Here we need only note that this topic shows Darwin at his best, with a practicable and ingenious invention to support a well-thought-out and novel theory.

The fourth canto, on 'Good and Evil', begins with the vivid picture of the struggle for existence, already noticed in Chapter V. After the verses on animals, quoted in part on page 74, he turns to insects:

> The wing'd Ichneumon for her embryon young
> Gores with sharp horn the caterpillar throng.

The cruel larva mines its silky course,
And tears the vitals of its fostering nurse.
(IV. 33-6)

Then, after the lines on war among the plants quoted on page 74, he looks at the sea:

In ocean's pearly haunts, the waves beneath
Sits the grim monarch of insatiate Death;
The shark rapacious with descending blow
Darts on the scaly brood, that swims below . . .
(IV. 55-8)

The world, then, is a mere slaughter-house. Man suffers as much as any — perhaps more, because of artificial ills like slavery, war, religious mania, alcohol and avarice:

Here ragged Avarice guards with bolted door
His useless treasures from the starving poor;
Loads the lorn hours with misery and care,
And lives a beggar to enrich his heir.
(IV. 97-100)

Is there nothing to hear, then, but 'one universal groan'?

Ah where can Sympathy reflecting find
One bright idea to console the mind?
(IV. 131-2)

Darwin, through his spokeswoman the Hierophant, replies that Good and Evil are, for man, nicely balanced. On the side of Good is, first, the very joy of living, the tingling of the blood in the veins. Next come the delights of Nature — flowers, streams, varied landscapes — the pleasures of Love, and the enjoyments of music, painting and all the imaginative arts. Then there are the satisfactions of patriotism and philanthropy, and the triumphs of science, from Newton's sublime concepts to the practical grasp of Archimedes or inventions like the steam engine. Printing has speeded the advance of knowledge, and the press must remain free, to save

The tree of knowledge from the axe of power.

Technology exists to serve Man, and Darwin foresees some of its future achievements, including skyscrapers, piped water — and traffic jams:

Bid raised in air the ponderous structure stand,
Or pour obedient rivers through the land;
With cars unnumber'd crowd the living streets,
Or people oceans with triumphant fleets.
(IV. 315-8)

At the end, however, Darwin discards his rose-tinted spectacles and reverts to the survival of the fittest. A single aphis could have a progeny of over 2 billion in the course of its ten generations in summer, 'ten thousand seeds each pregnant poppy sheds', the herring spawns profusely —

All these, increasing by successive birth,
Would each o'erpeople ocean, air, and earth.
So human progenies, if unrestrain'd,
By climate friended, and by food sustain'd,
O'er seas and soils, prolific hordes! would spread
Erelong, and deluge their terraqueous bed;
But war, and pestilence, disease, and dearth,
Sweep the superfluous myriads from the earth.
(IV. 367-74)

But, since 'every pore of Nature teems with Life', new organisms soon spring up to counterbalance the death of 'a Monarch or a mushroom', as the fable of the Phoenix implies. So Darwin leads up to his philosophy of organic happiness, discussed in Chapter V. 'The sum total of the happiness of organized nature is probably increased rather than diminished, when one large old animal dies, and is converted into many thousand young ones' (IV. 410, note). He emphasizes too

how restless atoms pass
From life to life, a transmigrating mass;
(IV. 419-20)

to-day they may be in poisonous henbane, and to-morrow in a Beauty's smile. After explaining that rocks are often 'mighty monuments of past delight', he concludes:

Shout round the globe, how Reproduction strives
With vanquish'd Death, — and Happiness survives;

How Life increasing peoples every clime,
And young renascent Nature conquers Time.
(IV. 451-4)

The Muse and the attendant nymphs are astonished at this exposition, as well they might be, and recover their poise by moving in procession down 'leaf-wove avenues' and through brazen gates to the Temple of Nature. There they sing hymns in honour of the evolutionary process, and Urania

Lifts her ecstatic eyes to TRUTH DIVINE!

2

How are we to judge Darwin as a poet from his performance in *The Botanic Garden* and *The Temple of Nature*? Which is nearer the mark, Horace Walpole's extravagant praise, or the world's subsequent contempt?

Historically, Darwin was in an unfortunate position as a poet, being the last of a line which deserved to be superseded, and was. For him poetry was little more than prettified prose, facts robed in finery. He had no inkling that his view would so soon be ousted by the Romantic ideal of poetry as the true voice of feeling. In the last hundred years poetry has retreated still further from the factual and actual, and even from the fictional, with the decline of narrative verse. Darwin's verse takes its origin not from emotion spontaneously recollected in tranquillity, but from scientific facts and theories purposefully worked into neat couplets. 'Nothing is done in passion and power. . . . Every line is as elaborately polished and sharpened as a lancet.' [5] To-day, bound as we still are by the Romantic concept of the poet, we cannot possibly regard Darwin as a great poet.

Despite these strictures, it seems to me that Darwin deserves a distinguished place among minor poets, because he was a first-class verse-technician, almost the equal of Pope, and because of his unique success in popularizing science by incorporating it imaginatively in verse. His skill in versification was acclaimed in the 1790s and has never been denied, although the demands of the rhyming sometimes lead him into pompously vapid statements about abstractions, which now seem ludicrous or distasteful. To his skill in verse-making he added a capacity for coining the memorable phrase. One of his severest Victorian critics, G. L. Craik, had to admit that 'no writer has surpassed him in the luminous representation of visible objects in verse'.[5] He was both original and successful in weaving scientific discoveries and theories into poetry, thereby giving 'to the British Parnassus a wider extent than it possessed in Greece',[6] in Anna Seward's curious phrase. All subsequent attempts to widen the British Parnassus in this way have failed (excluding Alfred Noyes's saga of the history of science, *The Torch-Bearers*, which is in a different category). So Anna Seward may have been right in thinking that *The Botanic Garden* 'will probably never have an equal in its particular class'.[6] Darwin's success in weaving natural history into poetry was more than mere virtuosity, however: it showed real imaginative grasp. For this feat Darwin has recently been earning some long-overdue recognition from literary critics, particularly from Bernard Blackstone in *The Consecrated Urn*, and from Elizabeth Sewell who, in *The Orphic Voice*, treats him on almost equal terms with Bacon, Goethe and Wordsworth, and calls *The Temple of Nature* 'a noble poem'.[7]

To sum up, it is fair to say that Darwin's verse oscillates between the brilliant (when his great skill in versification chimes in with his subject) and the ludicrous, when a conclusive-sounding couplet says nothing worth saying. At its best his verse is original and unique for incorporating scientific facts and theories in a harmonious and telling manner, and it was also unique as the only best-selling scientific poem in English. For these achievements he deserves to stand above those minor poets who, while sharing with him a facility for verse, have no distinctive vein of their own.

NOTES TO VII: *THE TEMPLE OF NATURE*

1. See A. I. Oparin, *Life: its Nature, Origin and Development* (1961), p. 62.
2. See C. Singer, *History of Biology*, p. 477.

3. F. Galton, *Hereditary Genius* (Watts, 1950), pp. 124-33.

4. P. C. Ritterbush, *Review of English Studies, XIII*, 158-60 (1962).

5. G. L. Craik, *History of English Literature*, (3rd ed., 1866), II. 382-3.

6. Seward, p. 178.

7. E. Sewell, *The Orphic Voice*, p. 244. *The Temple of Nature* is also the subject of a study by Irwin Primer, to be published in *Journ. Hist. Ideas* in 1964. A Russian translation of *The Temple of Nature* was published by the U.S.S.R. Academy of Sciences, Moscow, 1954. See C. A. Hoare, *Annals of Science*, **11**, 255-6 (1955).

VIII

INFLUENCE OF THE POEMS

I would like the reader to think of him as a churchyard yew, spreading his wide branches in storm and sunlight over the more remarkable writers who follow him.

BERNARD BLACKSTONE, *The Consecrated Urn*

1

THE theme of this chapter is Darwin's reputation as a poet and the influence of his verse and ideas on the great Romantic poets, particularly Wordsworth, Coleridge and Shelley.

In 1789, when Darwin's first poem *The Loves of the Plants* came out, the gentry and professional classes in England had enjoyed comparative freedom of opinion for fifty years. Provided they paid lip-service to the Church of England, they could, without ostracism, shelter behind a vague Deism if they felt that some details of Christianity were impossible to believe. This easy-going attitude prevailed because the social structure seemed stable: everyone tacitly assumed that God would continue to bless the squire and his relations and keep lesser mortals in their proper stations. This assumption was shattered by the French Revolution, and the ideal of an orderly stratified society, with the upper strata enjoying freedom of thought and of behaviour,[1] gradually crumbled during the 1790s in face of the growing alarm felt by the government at the excesses in France. By the end of the 1790s the climate had changed completely. As the *Annual Register* for 1798 noted: 'It was a wonder to the lower orders, throughout all parts of England, to see the avenues to the churches filled with carriages. This novel appearance prompted the simple country-people to inquire what was the matter.'[2] In these circumstances a pamphlet against Church or State was liable to be a passport to Botany Bay, and, even when they escaped direct action, those who sought to subvert the established order in politics or religion found themselves under continual attack.

This turn-about of opinion explains the strangely different reactions to Darwin's poems. *The Loves of the Plants* (1789) and the completed *Botanic Garden* (1791) were, despite their unorthodoxy, greeted with a chorus of almost unqualified praise, as we have already seen.[3] At first, *Zoonomia* (1794) was also favourably received. The *Monthly Magazine* thought it 'one of the most important productions of the age'.[4] But soon its evolutionary theory came under attack. The *British Critic* complained that Darwin discarded 'all the authority of revelation, only to substitute the sports of his own imagination';[5] by stressing man's affinity with the lower animals, he virtually denied the existence of the soul. And in Thomas Brown's lengthy *Observations on the Zoonomia* Darwin was also condemned for materialism.

1794 can be regarded as the year in which the tide turned against Darwin, for it also saw the first full-scale attack on him, a long poem entitled *The Golden Age*, alleged to be 'from Erasmus D——n M.D. to Thomas Beddoes M.D.'. The ideas of Beddoes and Darwin are heaped together for ridicule: we are shown Beddoes's picture of a Golden Age when the hedges are dripping with butter, and Darwinian plants, boiling with passions. The anonymous author then implies — and no abuse could be viler in 1794 — that Beddoes and Darwin are Democrats and Atheists:

> Ranks and Distinctions cease, all reeking lie
> In the mean muck of low Equality! . . .
> No more that lazy Lubbard shall we pay
> With phiz so farcical to preach and pray. . . .[6]

Finally, all Nature's creatures are asked to praise the democratic-atheistic Golden Age:

> Ye lovely Lambkins, strain your feeble voice
> And with your Dams in loudest Baas rejoice! . . .
> And ye, oh! Swine, lift up your little Eyes,
> With rapture riot round your rotten Styes![7]

Though the poem misrepresents Darwin, it has a rude energy, and it shows how, by 1794, he was being widely condemned for his opinions.

In 1797 the *Anti-Jacobin* periodical was founded, with the aim of combating all ideas subversive to the established government or religion. It was a semi-official publication, controlled by Canning, Foreign Under-Secretary in Pitt's government. Canning thought Darwin's evolutionary ideas dangerous, for although the word *evolution* was not used, he recognized that evolution and revolution had much in common: both brought change into a comfortably static situation. So Canning, with two collaborators, Hookham Frere and George Ellis, set out to destroy Darwin's reputation — and did so — with a parody, *The Loves of the Triangles*, written in ultra-Darwinian verse and published in three numbers of the *Anti-Jacobin*, for 16 April, 23 April and 7 May 1798.

To-day *The Loves of the Triangles* seems feeble: occasionally it detonates, but only to damage its authors. Like *The Golden Age*, the poem aims to fell two radicals with one blow, for, though dedicated to Darwin, it is alleged to be written by a Mr. Higgins, meant to represent Godwin, who is also ridiculed. Canning and his collaborators use the jejune technique of exploiting all the sexual implications of mathematical terms, such as the osculation of curves. A parabola, a hyperbola ('blue-eyed wanton') and an ellipse are made to sigh for the love of a rectangle. These ludicrous themes are justified in heavily facetious Notes.

At its best, however, *The Loves of the Triangles* does score off Darwin, by imitating his style and applying it to trivial subjects, as when the Nymph of the Wheel eyes her beloved Smoke-Jack:

Mark how his various parts together tend
Point to one purpose, — in one object end:
The spiral *grooves* in smooth meanders flow,
Drags the long *chain*, the polish'd axles glow,
While slowly circumvolves the piece of beef below:
The conscious fire with bickering radiance burns,
Eyes the rich joint, and roasts it as it turns.

So youthful Horner roll'd the roguish eye,
Cull'd the dark plum from out his Christmas pye,
And cried in self-applause — 'How good a boy am I!'[8]

Having done their best to make Darwin a laughing-stock, the authors bombard him with sarcastic Notes restating his allegedly foolish ideas — particularly the beliefs that men have evolved from lower forms of life, that electricity will have important practical applications and that the mountains are much older than the Bible says. Since all three of Darwin's ideas are correct, Canning's weapon has proved to be a boomerang, which posthumously returned to smash his reputation as a parodist: or, rather, it would have done if the literary historians had realized that Darwin had proved to be correct. But they did not, and so the parody continues to be accepted as retaining its original lethality. *The Loves of the Triangles* now deserves to be noticed, if at all, chiefly as a warning to parodists not to ridicule a theory which may be true, let alone *three* theories which turn out to be true. Again Darwin has the last laugh; but it is rather a hollow one, because nothing can alter the fact that the parody did kill his reputation as a poet.

In 1797, the year before *The Loves of the Triangles* appeared, Darwin's fame was unquestioned. Coleridge detested his verse — 'I absolutely nauseate Darwin's Poem',[9] as he ambiguously put it — yet had to admit that Darwin was 'the first *literary* character of Europe'. In 1803, however, we find the *Edinburgh Review* referring to 'his decline from the exalted place he once appeared to hold',[10] and in 1812 Byron was writing him off as a 'mighty master of unmeaning rhyme'. Some remnants of his old reputation lingered, however, and G. L. Craik, in his popular *History of English Literature* in the 1860s, although hostile to Darwin, still gave ~~him~~ twice as much space as Shakespeare (and ~~six~~ times as much as Byron). After Craik's elaborate demolition, it became customary to condemn Darwin's verse without reading it, an attitude which has persisted. For example E. V. Lucas, in his chapter on Darwin in *A Swan and her Friends*, coolly remarks, 'his methods I propose to display by a burlesque';[11] he then quotes the 284 lines of *The Loves of the Triangles*, but not one of Darwin's own. Most authors are judged by what they have written; but Darwin, it seems, has to forgo this basic right.

When *The Temple of Nature* was published in 1803, its reception was predictable. The poem was generally condemned for its 'total denial of any interference of a Deity',[12] in the words of the *Anti-Jacobin Review*, while the *Critical Review* attacked Darwin for trying 'to substitute the religion of nature for the religion of the Bible'.[12] Sales were small, and Darwin's best statement of his evolutionary theory was little noticed.

Although Darwin's popularity was thus snuffed out in the late 1790s, he still influenced the great English poets of his time. In *The Botanic Garden* he staged a marvellous display of Nature's variety and profundity, and showed his sympathy with the revolutionary cause: both these features appealed to Wordsworth and Coleridge, who were 21 and 19 respectively when the poem appeared. Twenty years later Shelley came to admire Darwin, both for these reasons and because he showed how to infuse poetry with science. Darwin's verse also 'made its mark on Blake, Byron . . . and Keats'.[13]

2

Wordsworth's best years as a poet were between 1797 and 1807, and it is generally agreed that his crucial formative period was from 1791, when he left Cambridge (where he had been at Darwin's college, St. John's), until 1797. It is also generally accepted that Wordsworth was at his best from 1797 to 1807 because of the stimulus provided by (1) revolutionary ideas and free-thinking, (2) his 'discovery' of Nature and its integration into his poetry, and (3) the new verse technique he developed, which displaced the artificial eighteenth-century methods. These three latent seeds germinated in 1797 and succeeding years, chiefly, it seems, as a result of his friendship with Coleridge.

How did the seeds become implanted, between 1791 and 1797, and create a state of mind conducive to great poetry? The obvious stimuli from external events are the French Revolution and Wordsworth's travels in France in the early 1790s. But the most important intellectual stimulus came from Darwin, whose poems and ideas had a profound effect on Wordsworth.

Wordsworth's first long poem, the *Descriptive Sketches* (1793), is in Darwinian couplets and is thoroughly imbued with the worst features of Darwin's style — the rather pompous or indirect statement of trivialities — while ignoring the better features, like the flashes of humour and the acute scientific verses. Some snippets from the *Descriptive Sketches* will show Wordsworth's Darwinization:

> Soft bosoms breathe around contagious sighs,
> And amorous music on the water dies. . . .
> Contentment shares the desolate domain
> With Independence, child of high Disdain. . . .
> Where bleeding Sidney from the cup retired,
> And glad Dundee in 'faint huzzas' expired.
> (lines 105-6, 260-1, 301-2)

Though it is rather unfair to quote Wordsworth at his worst, he still often lapsed into pompous statement even after he had rejected the artificial Darwinian style; and such lapses can fairly be regarded as a lingering after-effect of drinking too deep at the Darwinian spring when young. In fairness to Darwin, too, it must be admitted that he influenced some of Wordsworth's better lines. For example,

> All shod with steel,
> We hissed along the polished ice,

in *The Prelude*, may well derive from Darwin's line

> Hang o'er the gliding steel, and hiss along the ice.[14]

Also, Darwin was among Wordsworth's earliest admirers: Christopher Wordsworth reported his brother's high repute with Darwin in 1793.[15, 18]

There are two other unquestionable borrowings from

Darwin among Wordsworth's poems. First, he took the story of *Goody Blake and Harry Gill* direct from *Zoonomia* (II. 359). Second, Wordsworth was obviously impressed by Darwin's account, in *The Economy of Vegetation*, of Cambyses's army being buried in sand after a storm. Darwin ends with

> awhile the living hill
> Heaved with convulsive throes, — and all was still!
> (II. 497-8)

In Wordsworth's *To Enterprise*, written some thirty years later, we find

> An Army now, and now a living hill
> That a brief while heaves with convulsive throes —
> Then all is still.
> (lines 114-16)

During the years when he was under Darwin's spell, Wordsworth utilized his ideas, subject-matter and technique. Darwin strongly approved of the French Revolution, which for Wordsworth made it bliss to be alive in that dawn; and Wordsworth's strain of pantheism owes something to Darwin's idea that God, if existing at all, was at best a remote entrepreneur of Nature. *The Botanic Garden* is largely concerned with Nature, full of exact descriptions, and particularly strong on flowers: and the same words would serve to describe Wordsworth's whole poetic output. Wordsworth's dependence on Darwin's verse technique did not last long: he saw it was barren and became disgusted with it. His famous preface to *Lyrical Ballads*, which expresses that disgust, is one long blast against poems like those of Darwin: when Wordsworth refers to the 'gaudiness and inane phraseology of many modern writers',[16] Darwin is his target. Nevertheless, Wordsworth fortunately retained the good habit of describing Nature in detail, from actual observation.

So Darwin impressed on Wordsworth democratic-atheistic ideas, with assistance from the French Revolution and Godwin; Darwin, with help from Rousseau, probably gave Wordsworth the idea of making Nature the main subject for his poetry; and Darwin supplied him with a poetic style so moribund that it forced him to forge a new style for himself.

Darwin was therefore responsible, at least in part, for each of the three main attributes of Wordsworth's greatness. Without Darwin, Wordsworth's poetry might possibly have been a pale shadow of what it is.

Not all Wordsworth's interpreters admit Darwin's influence, though two at least, E. Legouis and H. W. Garrod, have accepted it: 'Wordsworth had his period of infatuation for Darwin . . . he was among those who, for some years, extolled *The Botanic Garden* to the skies' (Legouis).[17] 'Wordsworth's poetic theory and practice in this period [*c.* 1792] are derived from Erasmus Darwin. . . . It is, I think, more than likely that . . . he was in part responsible for the revolutionary and free-thinking turn given to Wordsworth's mind in 1791 and the following years' (Garrod).[18] Darwin's negative influence — in making Wordsworth rebel against poetic diction — has been stressed by A. Beatty.[19]

3

Coleridge scorned Darwin's poems, 'but they had an uncanny fascination for him nevertheless', as J. Livingston Lowes remarked in *The Road to Xanadu*, where Darwin's influence on Coleridge is traced in masterly detail.[20] Coleridge used the notes to Darwin's poems as a treasure-chest of curious lore, and often reproduced his phrases. Two of the examples given by Lowes are concise enough to be summarized here. First, Darwin notes that 'the light of small stars are seen undiminished through both the light of the tails of comets and of the aurora borealis', a statement he versifies (for comets) as

> The wan stars glimmering through its silver train.[21]

Coleridge follows with the famous verse on the aurora in the *Ancient Mariner*, beginning 'The upper air burst into life', and ending:

> The wan stars danced between.

Second, Darwin, in describing the dust-laden desert wind, the Simoom, in *The Economy of Vegetation*, says it 'rides the tainted air' (IV. 67), which Coleridge echoes in *Religious Musings* with

> through the tainted noon
> The Simoom sails.
>
> (lines 268-9)

Lowes missed other possible parallels. For example, we might set the lines from *Kubla Khan*,

> Five miles meandering with a mazy motion . . .
> . . . gardens bright with sinuous rills,
> Where blossomed many an incense-bearing tree,

beside these from *The Economy of Vegetation*:

> Liffy pours his bright meandering waves. . . .
> And in new veins the gushing rills direct. . . .
> And blossom'd orchards stretch their silver shade.
> (III. 460, 466, 468)

Or there is Darwin's account of phosphorescence in the sea, in Note IX of *The Economy of Vegetation*: 'as a ship floats along, it seems during the night to be surrounded with fire, and to leave a long tract of light behind it. Whenever the sea is gently agitated it seems converted into little stars, every drop as it breaks emits light. . . .' This recalls the lines in the *Ancient Mariner* —

> I watched the water-snakes:
> They moved in tracks of shining white,
> And when they reared, the elfish light
> Fell off in hoary flakes.

There are thirty-five references to Darwin in the index to Volumes I and II of Coleridge's *Notebooks*, and their editor, Kathleen Coburn, has noted[22] two other possible echoes of Darwin in the *Ancient Mariner*, both stemming from *The Loves of the Plants*. Darwin's lines

> And ever and anon with hideous sound
> Burst the thick ribs of ice, and thunder round
> (IV. 351-2)

were possibly still reverberating in Coleridge's mind when he wrote

> The ice was all around:
> It cracked and growled, and roared and howled,
> Like noises in a swound! . . .
> The ice did split with a thunder-fit. . . .

Also Darwin's

> dim amid the distant foam she spies
> A rising speck — ''tis! 'tis he!' she cries
> (IV. 371-2)

may well foreshadow the Mariner's sighting far away over the sea of 'a something' —

> At first it seemed a little speck,
> And then it seemed a mist. . . .

Coleridge complained that Darwin's poetry 'arrests the attention too often' [22]: it certainly arrested his.

Keats also had a poor opinion of Darwin's verse, yet still was influenced by him. Trains of virgins moving towards flowered altars are frequent in Darwin's poems, and Keats seems to proceed along the same lines in the Odes to *Psyche* and the *Grecian Urn*. In *The Temple of Nature*, for example,

> Long trains of virgins from the sacred grove,
> Pair after pair, in bright procession move,
> With flower-fill'd baskets round the altar throng,
> Or swing their censers, as they wind along.
> (I. 159-63)

This can fairly be called Keatsian, and resembles lines from the *Ode to Psyche*:

> Nor altar heap'd with flowers;
> Nor virgin-choir to make delicious moan. . . .
> From swingèd censer teeming;
> Thy shrine, thy grove, thy oracle. . . .

Bernard Blackstone in his book *The Consecrated Urn* has argued that Keats was deeply influenced by Darwin's expositions of organic growth: 'Indeed, his life's work is in one sense a correction of Darwin. . . . The journey we go from the calixes of 'small buds unfolding' in the early *Sleep and*

Poetry to the ultimate *Grecian Urn* is the same journey we go from the opening plates of urn-like seed-cases and flowers in *The Loves of the Plants* to the concluding engravings of the Portland Vase in *The Economy of Vegetation*.' [23] Even if Keats is not quite so beholden to Darwin as Blackstone contends, the great poet who studied medicine certainly owed something to the great doctor who wrote poetry.

Of all the Romantic poets it was Byron who reacted least against the rhyming couplets used by Darwin; and yet his poetry offers few parallels with Darwin. It is of interest, however, that Mary Shelley's *Frankenstein* was conceived after a long discussion between Byron and Shelley about 'the nature of the principle of life, and . . . the experiments of Dr. Darwin' [24] on the subject. After this conversation, which went on late into the night, Mary could not sleep: 'My imagination, unbidden, possessed and guided me. . . .' [24] — and *Frankenstein* was born. In the very first sentence of the book's preface Mary calls on Darwin to justify her physiological fiction, by saying he thought it to be 'not of impossible occurrence'. Darwin stands, then, as a father-figure over this first and most famous work of science fiction. But that germinal conversation between Shelley and Byron also shows that Darwin's ideas interested Byron, who was not the man to discuss an uncongenial subject until the early hours of the morning.

For William Blake, Darwin's ideas were infuriating rather than interesting. Blake passionately opposed the aims of the Lunar Society, which he satirized in his *Island in the Moon*.[25] He detested both its rationalistic approach and the activities of its members, especially Boulton and Watt, whose steam engines had led to the building of so many more 'dark Satanic mills'. To his chagrin Blake had to aid and abet the members, when to earn a living he accepted work as a designer of Wedgwood ware, and as an illustrator of Darwin's *Economy of Vegetation*, which celebrates the triumphs of the technology Blake abhorred. He had this poem of Darwin's 'often in mind in later years when he was writing his great symbolic poems — as a polar opposite'.[25]

4

Darwin influenced Shelley deeply, even more, I now feel, than is implied in my book *Shelley: His Thought and Work.* By forecasting the future triumphs of science, Darwin helped to inspire Shelley with enthusiasm for scientific progress, and with his poems he gave Shelley the idea of bringing science into poetry. Shelley went far beyond Darwin's rather mechanical versified science, and succeeded in infusing poetry with science, creating a unique style which is perhaps his greatest technical achievement. Shelley accepted Darwin as a mentor more eagerly because he too was a sceptic in religion, and opposed tyranny and slavery in all its forms. Darwin's approval of sexual pleasure helped to confirm Shelley in his free-love theory, which he later incorporated into a wider framework of Platonic Love. And Darwin's views that plants have emotions and that insects are our cousins find their expression in many of Shelley's poems.

After his six years at Eton, Shelley went up to Oxford in October 1810, seething with stifled rebellion. The University's motto is *Dominus illuminatio mea*, but Shelley aimed to illuminate its sleepy residents in quite another way. His campaign came to an untimely end, however, when he was expelled in March 1811 for refusing to deny he had written a pamphlet called *The Necessity of Atheism*, which he had vigorously distributed among the dons. For the next two years Shelley led a roving life: he tried to illuminate the Irish, assisted in embankment-repairs at Tremadoc, issued various political pamphlets and was shadowed by Government spies.

During these nomadic years, when Shelley is known to have read *The Botanic Garden*, *The Temple of Nature* and *Zoonomia*, he composed his first long poem, *Queen Mab*, a diatribe denouncing present evils — tyrants, slavery, war, commerce, luxury, religion, meat-eating, alcohol-drinking, etc. — and looking forward to a happier future. The spirit and subject-matter of *Queen Mab* are foreshadowed by

Darwin, first in *The Economy of Vegetation*, when he urges the gnomes to wreak vengeance on that 'guilty wretch'

> The blood-nursed Tyrant on his purple throne,

and, second, in Canto IV of *The Temple of Nature*, where he attacks superstition, slavery, alcohol, avarice, luxury, etc. Sometimes Shelley follows Darwin's sentiments exactly, for example, on ambition leading to war:

> While mad with foolish fame, or drunk with power,
> Ambition slays his thousands in an hour. (Darwin)
> When merciless ambition, or mad zeal,
> Has led two hosts of dupes to battlefield. (Shelley)[26]

or:

> And one great Slaughter-house the warring world! (Darwin)
> Making the earth a slaughter-house! (Shelley)[27]

Darwin is also partly responsible for the technique: Shelley brings in a stooge-Deity (Queen Mab) to speak for him, just as Darwin brings in Urania or the Goddess of Botany; and, like Darwin, Shelley provides detailed semi-scientific Notes which are longer than the poem.

Of Shelley's other major poems, his greatest, *Prometheus Unbound*, probably owes most to Darwin. Shelley's theme is the regeneration of the world through Universal Love: the new and happier world is described by the winged Spirit of the Earth —

> on its head there burns
> A light, like a green star, [with] emerald beams. . . .
> . . . as it moves,
> The splendour drops in flakes upon the grass!
> (III. iv. 2-5)

Darwin, in *The Temple of Nature*, also depicts a regenerated world, introduced by the Seraph Sympathy —

> bright o'er earth his beamy forehead bends;
> On Man's cold heart celestial ardor flings,
> And showers affection from his sparkling wings.
> (III. 468-70)

(Shelley's lines also no doubt include a reminiscence of Coleridge's 'elfish light', which 'fell off in hoary flakes'; but this too may derive from Darwin, as we noted earlier.) In Shelley's new world

> Love . . . folds over the world its healing wings
> (IV. 561)

and man's will

> Is as a tempest-wingèd ship, whose helm
> Love rules.
> (IV. 409-10)

Darwin's winged seraph

> charms the world with universal love,

a line which echoes one in the *Economy of Vegetation*,

> And Love and Beauty rule the willing world.
> (IV. 62)

Many details in *Prometheus Unbound* also seem to derive from Darwin. Shelley takes over Darwin's idea that the moon might support an atmosphere.[28] When Darwin rather stiffly equates magnetic attraction with love —

> So turns the needle to the pole it loves —[29]

Shelley seizes the concept and transmutes it into poetry:

> Like the polar Paradise,
> Magnet-like of lovers' eyes.
> (IV. 465-6)

This is typical of the way Shelley profits from, and at the same time transcends, Darwin's versified science. Sometimes the borrowing is more direct, as when in *The Economy of Vegetation* Darwin bids the 'ethereal powers'

> Ride, with broad eye and scintillating hair,
> The rapid Fire-ball through the midnight air,
> (I. 127-8)

and Shelley follows by making bubbles ride on meteors, for, when the air within the bubbles

> Ascends to flow like meteors through the night,
> They [the bubbles] ride on them. . . .
> (II. ii. 79-80)

When Shelley starts the spirits dancing in Act IV of *Prometheus Unbound* with

> Weave the dance on the floor of the breeze,

he was probably remembering the dance of the Nereids in *The Loves of the Plants*:

> In air and ocean weave the mazy dance. . . .
> (IV. 218)

Finally, the key line which ends Act III of *Prometheus Unbound*,

> Pinnacled dim in the intense inane,

is suspiciously like Darwin's

> Hung with gold-tresses o'er the vast inane.[30]

Carl Grabo, in his study of Shelley's use of science in *Prometheus Unbound*, has noted further resemblances.[31]

Of Shelley's other long poems, *Adonais* is linked with *The Temple of Nature*: in both the goddess Urania is brought in to weep over human wrongs and death, and then to provide some consolation. In Darwin's poem

> Urania paused, — upturn'd her streaming eyes,
> And her white bosom heaved with silent sighs;
> With her the MUSE laments the sum of things,
> And hides her sorrows with her meeting wings;
> Long o'er the wrecks of lovely Life they weep,
> Then pleased reflect, 'to die is but to sleep';
> From Nature's coffins to her cradles turn,
> Smile with young joy, with new affection burn.
> (II. 205-12)

In Shelley's poem Urania first laments her favourite Adonais and bemoans the world's injustice, and then denies his death by pointing to Nature's regeneration in spring:

> weep again!
> Lament anew, Urania! . . .
> . . . fans him with her moonlight wings, and cries:
> 'Our love, our hope, our sorrow, is not dead' . . .

Fresh leaves and flowers deck the dead Season's bier . . .
. . . he is not dead, he doth not sleep —
He hath awakened from the dream of life . . .
He is made one with Nature.[32]

Shelley's finest lyrics also probably owe something to Darwin. For Darwin particularly liked aerial phenomena, a taste shared by Shelley, whose most famous lyrics, the *West Wind*, the *Cloud* and the *Skylark*, are set in the sky. In Canto I of *The Economy of Vegetation*, one section is entitled 'Western Wind unfettered':

unbind
The struggling pinions of the WESTERN WIND. . . .
And wring the rain-drops from his tangled hair.
(I. 429-32)

Shelley also personified the West Wind in his Ode, and this last line of Darwin's, which is a memorable one, seems to have stuck in his mind. For Shelley's Wind

Shook from the *tangled* boughs of Heaven and Ocean,
Angels of *rain* and lightning . . .
Like the bright *hair* uplifted. . . .

In the *Cloud* the Darwinian flavour is much stronger. Canto III of *The Economy of Vegetation* is largely concerned with clouds and water, and the shower scene (lines 509-36) seems like a preview of

I bring fresh showers for the thirsting flowers,
From the seas and the streams. . . .

The process of water-circulation, expounded by Darwin in lines 11-56 of the same canto, is crucial in Shelley's poem from the first lines, quoted above, to the last, and is summed up as

I pass through the pores of the ocean and shores,

which derives from Darwin's

each nice pore of ocean, earth, and air.[33]

Finally, Shelley's *Sensitive Plant*, with its continuous personification of plants and its flower-catalogue, obviously stems from Darwin's idea that plants have emotions, an idea which, though much laughed at, has been influential. For although the idea was too extreme for even Wordsworth to accept, he and Shelley both utilized it in diluted form as the basis of that strain of empathy which is one of the Romantic poets' major contributions to literature. This 'personality cult' among plants and animals was carried to unseemly lengths by some of the Georgian poets, after having been condemned by Ruskin as 'the pathetic fallacy'. Yet Darwin's idea has staged a come-back in the last forty years: for speeded-up films of insectivorous plants feeding, or of Dodder and Convolvulus fighting, look horribly human; and Sir Jagadis Bose's experiments to show that plants such as mimosa have a central nervous system like animals, though unacceptable to many physiologists, have attained sufficient fame to enter into the philosophy of that toughest of twentieth-century characters, James Bond.[34]

Darwin also left his mark on Shelley's worst lyrics, and most deeply on the famously bad *Indian Serenade*, with its much-abused lines

> Oh lift me from the grass!
> I die! I faint! I fail!

which are sometimes alleged to prove Shelley a weakling. Darwin is to blame, however, as three excerpts from *The Loves of the Plants* show:

> 'I sink, I fall! oh, help me, help!' she cries. . . .
> 'I faint, I fall!' — *at noon* the Beauty cried,
> 'Weep o'er my tomb, ye Nymphs!' — and sunk and died . . .
> I faint! — I fall! — ah, me! . . .
> (I. 451, II. 331-2, IV. 263)

(Shelley's *fail* is less euphonious than *fall*; but he wanted a rhyme for *pale*.) So those who condemned Shelley should turn on Darwin: but who can imagine them calling the vigorous eighteenth-century doctor a weakling? Darwin would make mincemeat of them with that 'sarcasm of very keen edge'.

Echoes of Darwin often sound elsewhere in Shelley's work. The Hierophant (or 'expounder of mysteries') is the key figure in *The Temple of Nature*, and this uncommon word is used by Shelley in the famous conclusion of the *Defence of Poetry*: 'Poets are the hierophants of an unapprehended inspiration . . . the unacknowledged legislators of the world'. Both of them also like the word *printless*, as in Darwin's lines

> You trod with printless step Earth's tender globe. . . .
> Who glide unseen, on printless slippers borne,

and Shelley's

> The printless air felt thy belated plumes.[35]

Another parallel can be found in Darwin's lines

> From ocherous beds the swelling fountain flows;
> With streams austere its winding margin laves,

which seem to foreshadow Shelley's

> that mighty fountain;
> And where the flood its own bright margin laves.[36]

For Darwin hermaphrodites were more than a myth: they figured in his evolutionary theory (see page 124). This is one reason why hermaphrodites are prominent in Shelley's poems, particularly *The Witch of Atlas*. As a final example, Shelley makes the winds love the mountainous island in *Epipsychidion*,

> the blue heavens bend
> With lightest winds, to touch their paramour.
> (lines 544-5)

This splendid conceit derives from *The Loves of the Plants*, where the saline basil Ocyma, growing in the Andes,

> Mounts the rude cliff, unveils her blushing charms,
> And calls the panting zephyrs to her arms.
> (IV. 233-4)

The whole erotic intensity of *Epipsychidion* recalls Darwin's single-minded pursuit of sex in *The Loves of the Plants*, though Shelley has lifted the theme to a higher plane.

Shelley detested Darwin's style and said 'didactic poems are my abhorrence'; yet it is not surprising that 'Darwin made a profound impression upon Shelley's thought and imagination', as Carl Grabo put it.[37] For when Shelley came to develop his unique style of 'lyricized science', Darwin's work was the obvious starting-point. And, more important, Darwin had been unjustly attacked by reactionaries. Even the staid Dr. Stock, the biographer of Dr. Beddoes, admitted that Darwin 'has been assailed with unsparing severity, because his writings have been thought to glow with too ardent a love for freedom, and too keen an indignation against the oppressor'.[38] Shelley automatically admired anyone who had been vilified because he glowed with too ardent a love for freedom, and this alone is enough to explain his addiction to Darwin.

5

Darwin was influential in many subjects, though this chapter has been concerned with only one — the subject which by its very nature is best documented. His influence in the other fields is far more difficult to assess. We have come to accept his ideas on geology and graveyards; on mental illness and meteorology; on flying and photosynthesis; on nerve impulses and sewage disposal — to quote only a selection. But it is hard to say how much, if at all, Darwin's advocacy has helped towards the acceptance of his ideas. Again, he often originated, in conversation, ideas which others developed: Watt, Priestley and Wedgwood owed much to him, though we cannot now tell exactly what. Finally, there is his major contribution to the theory of evolution, the greatest upheaval in thought of the nineteenth century: he was the first to expound the theory properly, he saw all its implications, and the evolutionary philosophy which he propounded remains valid. This wide-ranging influence in scientific subjects is probably more important than the literary matters discussed in this chapter. But Darwin's hold over the Romantic poets is of particular interest because it represents the posthumous triumph of his much-maligned poems: the ideas he expressed came to influence the climate of thought through being ground fine by that subtle engine, the mind of a great poet, and then disseminated anew.

NOTES TO VIII: INFLUENCE OF THE POEMS

1. See D. P. Mannix, *The Hell Fire Club* (1961).
2. *Annual Register, 1798*, p. 229.
3. See Chapter VI; N. Garfinkle, *Journ. Hist. Ideas*, **16**, 378 (1955); and E. Robinson, *Annals of Science*, **10**, 314 (1954).
4. N. Garfinkle, *Journ. Hist. Ideas*, **16**, 380.
5. N. Garfinkle, *Journ. Hist. Ideas*, **16**, 384.
6. *The Golden Age* (Rivington, London, 1794), pp. 11, 14.
7. *The Golden Age*, p. 15.
8. Lines 51-60. *Poetry of the Anti-Jacobin*, p. 95. *Cf. Loves of the Plants*, II 93-104.
9. Coleridge, *Letters*, I. 216.
10. *Edinburgh Review*, July 1803, quoted by Logan, p. 20.
11. E. V. Lucas, *A Swan and her Friends*, p. 121.
12. Quoted by N. Garfinkle, *Journ. Hist. Ideas*, **16**, 386.
13. B. Blackstone, *The Consecrated Urn*, p. 13.
14. *Prelude*, I. 433-4; *Economy of Vegetation*, III. 570.
15. See C. Wordsworth, *Social Life at the English Universities in the Eighteenth Century* (Cambridge, 1874), p. 589.
16. Wordsworth, *Poetical Works* (O.U.P., 1946), p. 934.
17. E. Legouis, *The Early Life of William Wordsworth* (1921), pp. 137-8.
18. H. W. Garrod, *Wordsworth*, (2nd ed., 1927), pp. 55-6.
19. A. Beatty, *William Wordsworth*, (2nd ed., 1927), pp. 57-65.
20. J. L. Lowes, *The Road to Xanadu* (Vintage Books, 1959), pp. 18-19, 32-4, 87-92, 174-5, 420-1, 450.
21. *Economy of Vegetation*, Additional Note IV and I. 134.
22. *The Notebooks of S. T. Coleridge*, ed. K. Coburn (1957), vol. i, *Notes*, No. 174 and *Text*, No. 132.
23. B. Blackstone, *The Consecrated Urn*, p. 337.
24. Preface to 1831 edition of *Frankenstein*.
25. See B. Blackstone, *English Blake* (1949), pp. 19-26.
26. *The Temple of Nature*, IV. 103-4; *Queen Mab*, VI. 178-9.
27. *The Temple of Nature*, IV. 66; *Queen Mab*, VII. 48. For other resemblances, see C. Grabo, *A Newton among Poets*, pp. 22-7, and K. N. Cameron, *The Young Shelley* (1951), p. 245.
28. *Economy of Vegetation*, II. 82, note, and *Prometheus Unbound*, IV. 356-69.
29. *Loves of the Plants*, I. 315.
30. *Economy of Vegetation*, I. 98.
31. C. Grabo, *A Newton among Poets*, pp. 118-200, *passim*.
32. *Adonais*, lines 28-9, 83-4, 158, 343-4, 370.
33. *Economy of Vegetation*, I. 85.
34. See J. Bose, *The Nervous Mechanism of Plants* (1926), and I. Fleming, *Moonraker* (1959), p. 112.
35. *Economy of Vegetation*, II. 33, 501; *Prometheus Unbound*, II. i. 34.
36. *Loves of the Plants*, II. 396-7; *Revolt of Islam*, 4614-5.
37. C. Grabo, *A Newton among Poets*, p. 200.
38. J. E. Stock, *Life of Thomas Beddoes*, p. 50.

IX

INVENTIONS

> . . . inventions to delight the taste.
>
> SHAKESPEARE, *Pericles*

WE now make the abrupt transition from Darwin's influence as a poet to his mechanical inventions. Few influential poets have been recognized as inventors; fewer still have also been famous as propounders of speculative but often correct scientific theories; none, it is safe to say, has also been acknowledged as the best physician of his time. Darwin was unique in the way he overflowed the usual boundaries of achievement.

Darwin's inventions fall into three categories: some were fully engineered under his direction and of proved practical worth; some are of comparatively little interest, or are as yet untried; and some, though only designs on paper, were later re-invented and engineered successfully by others. Along with these inventions it is also worth reviewing some of his contributions to the *Philosophical Transactions* of the Royal Society, in which he combines invention with scientific research.

One of the most famous of Darwin's inventions, which still seems impressive, was his speaking-machine. Before constructing this machine he developed a theory of articulate sound. Discarding the alphabet as misleading, he divides the sounds of speech into four classes: (1) clear continued sounds, vowels; (2) hissing sounds, sibilants; (3) semi-vocals, a mixture of (1) and (2); and (4) interrupted sounds, or consonants. He analyses the vibrations of the air which give rise to each. The vowels, for example,

> are produced by the streams of air passing from the lungs in respiration through the larynx; which is furnished with many small muscles, which by their action give a proper tension to the

extremity of this tube; and the sounds, I suppose, are produced by the opening and closing of its aperture; something like the trumpet stop of an organ, as may be observed by blowing through the wind-pipe of a dead goose. . . .

The hissing sounds are produced by air forcibly pushed through certain passages of the mouth without being previously rendered sonorous by the larynx; and obtain their sibilancy from their slower vibrations, occasioned by the mucous membrane, which lines those apertures or passages, being less tense than that of the larynx. . . .[1]

And so on, with much detail. He then proceeds to describe the exact formation of each sound:

P. If the lips be pressed close together and some air be condensed in the mouth behind them, on opening the lips the mute consonant P begins a syllable. . . .[1]

And similarly for every other sound. He found most difficulty, he says, with the vowels, especially in deciding where exactly in the mouth they were modulated.

With this wealth of theory behind him, he embarked on the construction of his speaking-machine, which he describes as follows:

I have treated with greater confidence on the formation of articulate sounds, as I many years ago gave considerable attention to this subject for the purpose of improving shorthand; at that time I contrived a wooden mouth with lips of soft leather, and with a valve over the back part of it for nostrils, both which could be quickly opened or closed by the pressure of the fingers, the vocality was given by a silk ribbon about an inch long and a quarter of an inch wide stretched between two bits of smooth wood a little hollowed; so that when a gentle current of air from bellows was blown on the edge of the ribbon, it gave an agreeable tone, as it vibrated between the wooden sides, much like a human voice. This head pronounced the p, b, m, and the vowel a, with so great nicety as to deceive all who heard it unseen, when it pronounced the words mama, papa, map, and pam; and had a most plaintive tone, when the lips were gradually closed. My other occupations prevented me from proceeding in the further construction of this machine; which might have required but thirteen movements, as shown in the above analysis, unless some variety of musical note was to be added to the vocality produced in the larynx; all of which movements might communicate with the keys of a harpsichord or forte piano, and perform the song as well as the accompaniment; or which if built in a gigantic form, might speak so loud as to command an army or instruct a crowd.[2]

This description seemed worth quoting at length partly because it shows how much hard work went into some of his inventions — here he developed a theory of speech before he could begin — and partly because the machine created quite a sensation when it was first heard about 1770. In 1771 Matthew Boulton, a tough business man who would not be impressed by a mere toy, drew up a legal document, duly witnessed by Keir and Small, promising to pay Darwin £1,000 for a machine 'capable of pronouncing the Lord's prayer, the Creed and Ten Commandments in the Vulgar Tongue'.[3] However, the document may have been a joke, for the anti-Christian Darwin would scarcely have wished to provide the Church with a robot priest, whose novelty might have swelled congregations. (Also it is rather doubtful whether Boulton's precarious finances could have withstood the payment of £1,000.)

Another vocal device Darwin liked was the speaking-tube (though it can scarcely be called an invention, having been known to the ancients), and he had a tube fitted from his study to the kitchen. One day a country yokel who had brought a message was waiting alone in the kitchen, and was alarmed to hear a sepulchral and authoritative voice from nowhere demand, 'Bring me some coals'. Deciding, presumably, that such a request could only come from the Devil, wishing to stoke up hell's fires, the man fled, and would not come near the house again.[4]

Another unusual furnishing in his study, the pointer on the ceiling which showed the wind-direction, proclaimed Darwin's great interest in the wind, which fascinated him because of its limitless supply of free power waiting to be tapped. In attempts to utilize this power, he designed many horizontal windmills, one of which operated efficiently at

Etruria for fourteen years before being displaced by steam.[5] Later, as recorded in his Commonplace Book in 1779, he made a series of experiments on windmill design. First he tried the rotor naked, and found it turned 875 times in 84 seconds. Then he enclosed it in a square box with two sides taken off so as to present one corner to the wind, and the number of turns fell to 820. Next he added a horizontal board: there was a further decrease, to 804. Finally he added little wings and a board underneath, and managed to increase the turns to 1,053. In a footnote he remarks, 'N.B. I made all these experiments with great accuracy'.[6]

The end-product of his labours, as shown in *Phytologia*, had a four-bladed propeller fixed to the top of a rotating vertical shaft and housed inside an octagonal tower. The walls of the tower consisted largely of boards set at an angle (rather like a Venetian blind) to deflect the airflow upwards on to the blades of the rotor, thereby operating it efficiently whatever the wind direction. Darwin would be pleased to know that, although windmills have largely passed into disuse, his system of stators and rotors is the very basis of the modern jet engine's axial compressor.

The inventions which probably won Darwin most renown were his carriage-designs. Since most of his working day was spent uncomfortably 'on the road', he was painfully aware of the need for improved designs. Unfortunately, few descriptions of his novel vehicles have survived. One of his favourite designs 'was in the form of a garden chair, fix'd upon the axle-tree; the footboard terminated in an elastic pole',[7] which was connected to the top of a short vertical iron bar fitting into a socket in the saddle, so that the horse was free to move in any direction it wished. This was, no doubt, fine for the horse, but not so good for the human, as one of the cathedral clergy found in 1768: 'He took me with him to Burton in this carriage, and the horse took fright on the road at a barrow of gravel, thrown down by a labourer, employed in making the canal, called the grand trunk; and ran one of the wheels on the top of a hedge, a yard or two. The carriage received a violent shock, which I really believe injured the axle-tree; for it broke the next day in one of the streets of Rugeley.'[7] This was the occasion when Darwin fractured his knee-cap, and he apparently never used the carriage again.

The design which fascinated Edgeworth, however, was a four-wheeler, and it had the virtue of continuing to stand on four points when rotating, whereas with an ordinary crane-necked carriage the wheels lock, so that in effect the vehicle turns on three. Darwin's carriage was therefore able 'to turn in a small compass without danger of oversetting'.[8] Another singular design of Darwin's was 'a coal-cart with exceedingly high wheels, the body of which was fix'd under the axle-tree'.[7]

Yet another of Darwin's ideas for carriage-design was to use the wheel spokes as springs. Furthermore, he had each spoke made in the serpentine line of beauty, thus combining mechanical improvement with elegance. Wedgwood greatly admired a carriage of this type made by a Lichfield coach-builder.[9] The invention of spring-spokes was an important one, used to-day in every bicycle (though without the line of beauty), and Darwin does seem to deserve the credit for it.

He was also interested in mechanically-propelled carriages. In 1765 he sent Boulton diagrams of 'a fiery chariot', a locomotive steam-carriage worked by twin cylinders, which operated alternately. Darwin proposed going into partnership with Boulton to make the vehicle and patent it. But apparently the scheme fizzled out,[10] and the credit for the first working steam-carriage goes instead to the Frenchman Cugnot (1769). The first successful British steam-carriage was made at Redruth in 1784 by Watt's assistant, William Murdock. But Watt, plainly unimpressed by Darwin's enthusiasm for the idea, discouraged Murdock from proceeding further.

Another conveyance devised and brought to fruition by Darwin was a mechanical ferry across the river at Derby from his house to the orchard. Basically, this was a rather tub-like boat with a high post in the bow, to which the main tow-rope was apparently attached, while guide-ropes ran through the tops of four smaller posts along the sides of the boat. The only existing sketch of the ferry (by Darwin's son Francis, given in K. Pearson's *Life of Galton*, I. 16) is not detailed enough to make clear its mechanism; but it certainly worked, and, even if no new principles were involved, it shows us again Darwin the practical engineer.

After these examples of engineered inventions, we can skip quickly over the second class, those which remain mere curiosities. He designed a telescopic candlestick, which is not of burning interest now that the candle has been superseded. His 'improved' oil lamps often disappointed him: 'This is very bad and will not succeed', he wrote in his Commonplace Book. In his more fanciful moods he dabbled in perpetual-motion machines and 'factitious spiders' controlled by magnets, and he also designed a machine for moving chessmen mechanically. On the severely practical side he put much effort into stocking-frames, spinning-machines for mohair, and other improvements in textile machinery. He proposed various new surveying machines, seed-drills (see Chapter IV), electrical machines, bridges and weighing-machines.

Perhaps the most appealing of Darwin's inventions are those which remained mere paper-designs but were successfully engineered by others many years later. They range from the earth-bound to the astronautical.

An example of the mundanely practical is the detailed drawing of a water-closet, very like the modern type, which appears in his Commonplace Book.[11] It has a cistern which is normally kept filled, the water level being regulated by a float-valve. From the cistern, a pipe normally kept closed by a valve takes the water to the basin. The valve is opened, thus flushing the basin, by closing the cover of the basin, and the valve is shut again by the person opening the door to leave the room. So Darwin introduces a greater degree of automation than exists in modern designs. At the bottom of the basin is a valve (with pivot and counterweight), which swings open under the weight of the flushing water. Darwin thus fails to include the modern water-trap, but as if to anticipate this omission he writes across the drawing: 'There should be no valve at bottom but a stink trap'.[11] So Darwin completely foresaw the modern water-closet. The first British patent for a water-closet was taken out by Alexander Cummings in 1775, and an improved version was patented by Joseph Bramah in 1778. Darwin's design, made sometime between 1776 and 1784, is independent of these and more advanced than either. However, it must be admitted that Sir John Harington, who described a design for a water-closet in 1596 in his *Metamorphosis of Ajax*, deserves to figure more prominently in the history of cleanliness than Cummings, Bramah or Darwin.[12]

At the other extreme there is a sketch of what appears to be a rocket motor with hydrogen and oxygen as propellants, though diluted by ordinary air.[13] (The drawing was probably made about 1779 while the phlogiston terminology was still in use, the hydrogen being labelled 'inflam. air' and the oxygen 'dephlogist. air'.) In Darwin's sketch the hydrogen and oxygen are stored in separate containers and fed into a cylindrical combustion chamber with a length/diameter ratio of about 2 and an exit nozzle at one end, very like the propellant feed and combustion chamber of a modern rocket. Also Darwin rightly shows a greater volume of hydrogen than oxygen. In 1962 the most advanced design being considered for the final-stage rocket of the European Space Launching missile had an oxygen-hydrogen motor, and so had the upper stages of the U.S. Saturn moon-rocket; Darwin is therefore right up to date. Tsiolkovskii (1903) is usually credited with the idea of the oxygen-hydrogen motor.[14]

Half-way, as it were, between the water-closet and the rocket, comes Darwin's bird with flapping wings. Most previous designs for flying-machines (including those of Leonardo, which were, however, unknown in Darwin's day) were doomed to failure because the inventor did not face up to the problems of power. Darwin does recognize and overcome this problem — though it is still doubtful whether his machine would have worked. He proposed a coiled watch-spring to move the wings, the spring being rewound by successive charges of gunpowder. 'But the simpler way, and better,' he says, 'would be to have a copper globe fill'd with condensed air' [15] to provide the motive power. The nearest modern counterparts to his flapping wings are probably the control surfaces of guided missiles, and a globe of compressed air does indeed often provide their power. So again Darwin is right up to date.

He also proposed telescopes made of many small lenses, an idea which has recently been put into practice, though with mirrors rather than lenses, in the interferometer recently built at Sydney, Australia.[16]

Another device which fascinated Darwin was the polygrapher or copying-machine. Sketches for this occupy many pages of his Commonplace Book, some of them with 'false' at the bottom. Watt subsequently devoted much attention to copying-machines,[17] and may have acquired this interest from Darwin.

Darwin was also much concerned with pumps, and his design for a continuous-stream rotary pump with counter-rotating toothed wheels was apparently put into practice later.

Darwin's experiments with windmills, water-wheels and steam engines gave him the idea of the steam turbine. In his Commonplace Book [18] he draws a diagram of a multi-bladed turbine wheel fitting snugly within an iron cylinder and with a jet of steam directed on its blades. This is precisely the *modus operandi* of Parsons's steam turbines which came into use in the late nineteenth century. Thanks to their high efficiency, steam turbines still serve as the power generators in electricity generating stations and in most large ships. On the subject of ship propulsion Darwin also suggested that moving vanes at the rear, like the modern screw, might be better than paddles.[19] Watt made a similar proposal, but, like Darwin, never followed it up.

Water transport provoked the most massive of Darwin's inventions, the canal-lift. Canals normally climb hills by means of locks; but if the level changes greatly in a short distance, a flight of locks is needed. A flight of locks delays traffic, is tediously complicated and may be difficult to build — *e.g.* when linking a canal with a river which it passes over. Also water escapes from the upper stretches of a canal every time a lock is used. A lift can avoid these disadvantages and Darwin was quick to see the possibility of a successful design. To the boat using it, the lift is merely a large rectangular box open at one side, through which the boat enters. The open side is then double closed, and the box, which is held from above by chains, descends to the lower level; the opposite side is opened and the boat moves out. The key to success lies in the mechanics of the descent, which Darwin solved brilliantly, by his proposal that another identical box also filled with water should be used to balance the descending one. (In a prototype version he suggested a metal counterweight, but the extra box has the advantage that it doubles the possible capacity of the lift: one boat can go up while another comes down.) In his scheme both boxes hang by chains from a beam with pulleys, and the only force needed would be to overcome the friction of the chains on the pulleys. For, as Darwin notes triumphantly in his Commonplace Book, probably in 1777, 'the water box is always the same weight, whether the boat is in it or not, since the boat whether full or empty will detrude [displace] just as much water as its own weight'.[20]

The first canal-lift to be built in England, at Tardebigge on the Worcester-and-Birmingham canal in 1809,[21] was similar to Darwin's prototype version. It was not until the famous Anderton lift near Northwich was opened in 1875 that Darwin's more advanced double-lift came into use, though Fulton had taken out a patent for a double-lift in 1794. Many such lifts have been successfully operated: the Anderton one has a rise of 50 feet, but there are some in Germany, built in the 1930s, which take the great Rhine barges and have rises of over 100 feet.

Darwin's design for a canal-lift was merely one outcome of his keen interest in canals: for he saw how cheap transport would accelerate the progress of what we now call the Industrial Revolution, and he was among those who helped to inaugurate the canal era in England. James Brindley, the great canal engineer, was, in the 1750s, working as a millwright in Staffordshire. He was a friend of the Wedgwood family and in 1757 built at their pottery works a fine mill for grinding flints. The canal era can be said to begin in February 1758 when Brindley began his first canal survey, for the Trent-and-Mersey canal. The Duke of Bridgewater heard of Brindley's survey work, and in 1759 commissioned him to build the relatively minor 10-mile Worsley–Manchester canal, for which the Duke introduced a Parliamentary Bill in the same year. This canal was completed in 1761 and figures in the history books as inaugurating the age of canals in England. The Trent-and-Mersey canal, nearly 100 miles long, was a much more ambitious and difficult project. Brindley called it the Grand Trunk Canal because it would provide a link between East and West coasts, and because he foresaw, rightly, that other canals would branch out from it, to the Severn, the Thames and elsewhere, thus linking Liverpool, Hull, Bristol and London, and providing cheap transport from the industrial Midlands to ports on all coasts.

The leading campaigner for the Grand Trunk Canal was Wedgwood, and he received strong support from his friend Darwin.[22] In 1766 Wedgwood, as the chief promoter of the Canal, had the honour of cutting the first turf (which was solemnly wheeled away in a barrow by Brindley) and, as soon as the line of the Canal was decided, he established his new works at Etruria beside it. The Grand Trunk Canal runs south-east from the Mersey at Runcorn through the salt-producing areas of Cheshire to its summit at the 2,900-yard Harecastle Tunnel, and then down through the Potteries to just north of Lichfield where it turns north-east to join the Trent south of Derby (see map, page 1). In 1771 Darwin proposed making a narrow canal at his own expense to link Lichfield with the Grand Trunk, but after much correspondence with Wedgwood, Brindley and others the scheme was dropped.[23] Although the Grand Trunk Canal took over ten years to complete, it was still the first major canal in Britain, as well as the very first, major or minor, to be surveyed. Its construction spanned the whole of Brindley's career as a canal engineer: for the Harecastle Tunnel was still unfinished in 1772 when he died of diabetes, which went undiagnosed until Darwin was called in during his last illness. Though Darwin was unable to influence canal history by saving Brindley's life, he still deserves a more prominent place in that history than he usually receives—for helping to inaugurate this first major English canal and for originating the only major piece of mechanical equipment used on canals. By a happy chance the Anderton lift, the design of which Darwin anticipated 100 years before, raises boats from the river Weaver to the very canal he was associated with, the Grand Trunk.

Darwin's inventions, made mostly between 1765 and 1785, form an impressive array, and qualify him for some of the fame generally allotted either to nineteenth-century inventors or to that omnipresent figure, the anonymous inventor. It is unwise to be more specific in making claims for Darwin, because the history of invention is tentative and clouded in dispute: for usually no one bothered to describe early versions of inventions which did not come into practical use until much later, and their existence is rediscovered only by chance. Thus, although Darwin's inventions often antedate the accepted prototypes, some may themselves be antedated by the work of earlier inventors.

The inventor mediates between science and the man-in-the-street by applying scientific discoveries for the benefit of mankind. An inventor does not need to be especially skilled in science: what he must have is an intuitive 'feel' for the working of Nature and of mechanisms, a passionate interest in the details of machines and some subconscious desire to serve humanity. In the last 200 years prominent scientists have rarely concerned themselves with the invention of everyday mechanisms like carriages and water-closets: if a scientist has a mechanical bent, he usually turns to laboratory experiments in his own subject. Darwin was an exception to this rule: he was fascinated by scientific theory, to which he made many contributions; but his practical scientific interests, which were also strong, were expended mainly on his inventions — and, of course, on his medical work — rather than upon experiments in the subjects on which he theorized. It is difficult to think of anyone who excelled him as a scientific theorist and also as a practical inventor, except perhaps Leonardo da Vinci.

Although Darwin devoted little time to what we now call scientific research, he did enough to gain wide recognition, and he was elected a Fellow of the Royal Society in 1761. Several other members of the Lunar Society — Boulton, Wedgwood, Keir, Watt, Edgeworth, Priestley and Withering — as well as Darwin's son Robert, also became Fellows of the Royal Society. This invasion of the rather inbred and academic London scientific world by a whole group of Midlanders was a notable event, for none except Priestley was primarily a scientist, and apparently none had aristocratic connexions or other underhand means of effecting an entry. They seem to have prided themselves on their independence of London, which they rarely visited, and their contributions to the *Philosophical Transactions* of the Royal Society were (apart from Priestley's) few and far between: up to 1800 Wedgwood and Withering each contributed papers on 4 topics; Edgeworth, Keir and Watt 2 each; R. W. Darwin 1; and Boulton none. Beside them Erasmus Darwin, with 6 papers,[24] seems almost prolific.

Darwin's first contribution, 'Remarks on the Opinion of Henry Eeles Esq concerning the ascent of vapour', was in 1757. Eeles had argued that vapours only rise if they are electrically charged, but Darwin rightly refuted him. This, like most scientific papers of that day, is not of great interest now, and neither are two other of his contributions, 'An uncommon case of an Haemoptysis' (1760) and 'Experiments on Animal Fluids in the Exhausted Receiver' (1774). His paper 'Frigorific Experiments on the mechanical expansion of air' (1788) has already been discussed in Chapter VI.

The two remaining papers are worth inspecting more closely, because they illustrate his energy and originality, as a doctor and geologist-cum-engineer. The first of these papers, 'A New Case in Squinting' (1778), concerns a five-year-old boy, Master Sandford, who viewed every object with one eye (the one furthest from the object) by turning his head in such a way that the image fell on the blind spot on the retina of the nearer eye. Darwin suggests the condition was caused by his wearing, as a baby, a nightcap with appendages at each side visible only to the opposite eye. Darwin's proposed cure was to fit a large false nose like the gnomon of a sundial, which would force the boy to view with the near eye; but because of family troubles, the treatment was not pursued. Darwin saw the boy again six years later and found the habit more fixed. He made experiments which showed that Master Sandford, although each of his eyes was otherwise perfect, had blind spots four times larger than normal:

> Two circular papers, each of 4 inches diameter, were stuck against the wall, their centres being exactly at 8 inches distance from each other. On closing one eye, and viewing the central spot of these papers with the eye farthest from it, and then retreating 26 inches from it, the other paper became invisible. This experiment was made on 5 people, of various ages, from 10 years old to 40; and the paper disappeared to them all at about this distance, or an inch or 2 more or less: but to Master Sandford the paper disappeared at about 13 inches distance from the wall.[25]

This experiment, though not in itself very profound, does show us one reason why Darwin was so famous as a doctor. When he met a puzzling case he would go to much trouble devising experiments to elucidate it, even though in this instance he was confident that the use of the gnomon would, if persevered with, effect a cure.

The second paper, 'Of an Artificial Spring of Water' (1785), is concerned with artesian wells in theory and practice. Near Darwin's house at Derby, in swampy ground about 100 yards from the River Derwent, there was an old well about 12 feet deep 'which had been many years disused on account of the badness of the water'. At the bottom of the well was a bed of impervious red marl, and the water oozed from between the morass and the marl. The remainder of the story can best be told in his own words:

> Having observed that a very copious spring, called Saint Alkmund's well, rose out of the ground about half a mile higher on the same side of the Derwent, the level of which I knew by the height of the intervening wier to be about 4 or 5 feet above the ground about my well; and having observed that the higher lands at the distance of a mile or 2 behind these wells, consisted of red marl like that in the well; I concluded, that, if I should bore through this stratum of marl I might probably gain a water similar to that of St. Alkmund's well, and hoped that at the same time it might rise above the surface of my old well to the level of St. Alkmund's. With this intent a pump was first put down for the purpose of more easily keeping dry the bottom of the old well, and a hole about 2½ inches diameter was then bored about 13 yards below the bottom of the well, till some sand was brought up by the auger. A wooden pipe, which was previously cut in a conical form at one end, and armed with an iron ring at the other, was driven into the top of this hole, and stood up about 2 yards from the bottom of the well, and being surrounded with well-rammed clay, the new water ascended in a small stream through the wooden pipe. Our next operation was to build a wall of clay against the morassy sides of the well, with a wall of well-bricks internally, up to the top of it.[26]

This is a good example of Darwin putting one of his speculations to the test, and also utilizing the engineering skill which went into his inventions. The project was pursued further, however. 'Afterwards, to gratify my curiosity in seeing how high the new spring would rise, and for the agreeable purpose of procuring the water at all times quite cold and fresh',[26] he fixed a leaden pipe coming above ground level, and found that 2 hogsheads (105 gallons) of water per day could be collected at ground level, increasing to 4 hogsheads per day after the well had been flowing for a year.

He then goes on to discuss the geological principles behind such wells. Hills are often formed, he says, by the strata being raised from beneath. They are later worn away, so that strata exposed on hills often underlie those on the surrounding plains. The waters of ordinary cold springs, sliding between 2 of the strata above described, descend till they find or make themselves an outlet, and will in consequence rise to a level with the part of the mountain where they originated. And hence, if by piercing the earth you gain a spring between the 2d and 3d, or 3d and 4th stratum, it must generally happen, that the water from the lowest stratum will rise the highest, if confined in pipes, because it comes originally from a higher part of the country in its vicinity.[27]

Though the words *must generally* are too strong, Darwin has otherwise admirably summarized the principles of the artesian well. Such wells had been known for centuries; but Darwin was apparently the first to explain them properly, and there used to be a plaque on his house at Full Street, Derby, to commemorate the well in the garden as its most historic feature.

NOTES TO IX: INVENTIONS

1. *The Temple of Nature*, Additional Note XV, pp. 109-12.
2. *The Temple of Nature*, Additional Note XV, pp. 119-20.
3. Bolton, pp. 209-10. The original is to be found near the end of Darwin's Commonplace Book.
4. See H. Pearson, p. 30.
5. See Nora Barlow, *Notes and Records of the Royal Society*, vol. 14, no. 1, p. 90. For a sketch of the windmill, see E. Meteyard, *Life of Wedgwood*, II. 29.
6. Commonplace Book, p. 87.
7. Rev. R. G. Robinson, unpublished MS., quoted by M. A. Hopkins, *Dr. Johnson's Lichfield*, p. 96.
8. Edgeworth, p. 68.
9. See J. Wedgwood, *Life of Josiah Wedgwood*, p. 261.
10. See S. Smiles, *Lives of the Engineers, Boulton and Watt* (1904), p. 150.
11. Commonplace Book, p. 113.
12. See L. Wright, *Clean and Decent* (1960), pp. 71-5, 106-8.
13. Commonplace Book, p. 82.
14. See A. J. Zaehringer, *Soviet Space Technology* (1961), p. 9.
15. Commonplace Book, p. 38.
16. See R. Hanbury Brown, *New Scientist*, 12, 781-3 (1961).
17. See H. W. Dickinson, *James Watt* (1936), pp. 191-7.
18. Commonplace Book, p. 83 (date: probably 1779).
19. *The Temple of Nature*, II. 373, note.
20. Commonplace Book, p. 59.
21. See L. T. C. Rolt, *Inland Waterways of England* (1950), pp. 83-4.
22. See E. Meteyard, *Life of Wedgwood*, I. 407-11.
23. See E. Meteyard, *Life of Wedgwood*, II. 211.
24. *Phil. Trans.* **50**, 240 (1757); **51**, 526 (1760); **64**, 344 (1774); **68**, 86 (1778); **75**, 1 (1785); **78**, 43 (1788).
25. C. Hutton *et al.*, *Philosophical Transactions, abridged*, vol. 14, p. 301.
26. C. Hutton *et al.*, *Philosophical Transactions, abridged*, vol. 15, p. 628.
27. C. Hutton *et al.*, *Philosophical Transactions, abridged*, vol. 15, p. 630.

X

CONCLUSION

> From the formation of Planetary Systems to the blushing beauties of the humble Daisy, nothing escapes his attention.
>
> THOMAS TELFORD on Darwin

1

COLERIDGE, who was himself famous for his wide and curious knowledge, thought Darwin had 'a greater range of knowledge than any other man in Europe'. Because Darwin roams over such a vast territory, anyone writing a book about him ought: (1) to have been a doctor in general practice, so as to appreciate his medical activities; (2) to be proficient in every science, but especially botany, physiology, chemistry, geology, mechanics and meteorology; (3) to be well versed in the history of science and technology, so as to know which of Darwin's many ideas and inventions were (*a*) original and (*b*) fruitful; and (4) to be an experienced literary critic, so as to judge fairly his poems and their influence. I cannot claim this wide range of talent and experience, and am conscious of not having done Darwin full justice.

Even my account, however, has indicated the breadth of his knowledge and interests. It is perhaps worth bringing together from previous chapters the fantastic list of subjects in which he was a pioneer, in the sense that he advanced new and correct ideas: air travel, animal camouflage, artesian wells, aurorae, buds, canals, carriages, cloud formation, electrotherapy, exercise, fertilizers, geological strata, gill slits in embryos, interpreting the Portland Vase, linking body and mind, nerve impulses, night airglow, *ocular spectra*, organic happiness, origin and development of life, outer atmosphere, oxygenation of blood, photosynthesis, plant nutrition, recapitulation theory, rocket motors, seed-drills, sewage farms, sexual love, speaking-machines, steam turbines, submarines, survival of the fittest, telescopes, temperance, treating dropsy, treating mental illness, variations in species, vegetable animation, ventilation, water-closets, windmills, wind-vanes. The great variety of his interests has led to Darwin being underrated. As Harley Williams remarked: 'Erasmus Darwin was a "whole man", omnivorous of life, the opposite of a cloistered scholar; but diversity clouded his scientific reputation; his too manifold talent has caused him to be written off'.[1]

The wide range of his inventiveness provokes a comparison with Leonardo da Vinci. Each was a leader in his own profession, but Leonardo has the advantage that some of his masterpieces remain for us to see, whereas Darwin's masterstrokes of medical treatment do not, since he worked on perishable human material. Both also sketched a great variety of mechanical inventions, most of which were not engineered and remained almost unknown for nearly 300 years (Leonardo) or over 150 years (Darwin). Again Leonardo has an advantage: he was a better draughtsman than Darwin, and could make his unrealized inventions look more real. The similarity between them extends to the subjects of their inventions and speculations: both were interested in anatomy, anemometers, bridges, canals, canal locks, eyesight, fossils, geology, moving-wing aircraft, oil lamps, sewage disposal, spinning-machines, water-wheels, weighing-machines and wells;[2] but Darwin did not share Leonardo's interest in weapons. To call Darwin 'the Leonardo of Lichfield' would overrate his achievements, but may not so greatly overrate his abilities, of which he left a scattered and inadequate record.

The closest parallel to Darwin in his own day is offered by Goethe, whose fame as a poet has outlasted Darwin's. Though Darwin's achievements in science, technology and medicine were greater than Goethe's, their interests were curiously similar, for Goethe contributed to the theory of evolution and was, like Darwin, very interested in colour and spectra.

2

To end, it would be as well to sum up the picture of Darwin which emerges from the previous chapters. He was the foremost physician of his day, with an almost legendary reputation, and his skill was combined with great kindness and generosity. He would give poor patients not only free treatment but also food and blankets. He would travel 30 miles on Christmas Day 'to see a stranger with a stomach-ache'.[3] 'I have this day seen a Mrs. Riley of Stafford, who has a diseased digestion . . .',[4] he noted in his Commonplace Book on 25 December 1778.

His family and social life was full, and fully enjoyed: he had two happy marriages and fourteen children, and he was so active socially that his friends tend to dominate his biography. Despite a stammer, he was famous for his conversation, which bore out his reputation as the most knowledgeable man of his day, and was enlivened by wit and sarcasm.

As a scientific theorist Darwin's chief claim to fame is in the realm of evolution: he was the first to propound a satisfactory theory, with examples in support; he noted the crucial rôle of the 'survival of the fittest'; and he outlined the evolutionary process from life's origin as spontaneously generated microscopic specks in primeval seas to its present culmination in man. Erasmus has not been accorded the place he deserves in the history of evolution, chiefly because he is usually said to be Lamarckian in his views, a slander inaugurated by Samuel Butler (though with good intent, because he thought Lamarck was right) and reinforced by Bernard Shaw. In fact, as we have seen, Erasmus's version of the theory is rather less Lamarckian than the version presented by his grandson in the later editions of *The Origin of Species*, though Erasmus's examples of evolution in action were not numerous enough to convince the world; this remained for Charles Darwin to do, bringing patience, hard work and masterly argument to harden and clothe the outline provided by his grandfather.

There is a second reason why Erasmus's share in the theory of evolution has been undervalued. Some authors do admit that he was as correct as his successors, but then go on to dismiss him because his ideas, it is said, 'did not attract the attention of his contemporaries'.[5] In fact they did attract attention, and were thought important enough to warrant a satire from the Under-Secretary of State for Foreign Affairs, as well as being put on the Roman Catholic Index and drawing fire from many other quarters—scientific, political and religious—as we have seen. The only author, it seems to me, who has justly summed up Darwin's achievement is C. D. Darlington, in the chapter entitled 'The Great Precursor' in *Darwin's Place in History.*

On the subject of evolution, both geological and biological, Erasmus was able to see further than his contemporaries (and many of his successors), partly because of a fortunate accident. It happened that Darwin was strongly anti-Christian, and also that the Christian views on these subjects (which were generally accepted) were wrong. Consequently Darwin had a built-in bias in the right direction, whereas many of his successors, conditioned by Christianity, had to expend much subconscious effort in thinking themselves out of the wrong hypotheses in which their minds were imprisoned. Thus it was that Erasmus anticipated both the two great revolutions in scientific thought in the mid-nineteenth century: Lyell's *Principles of Geology* (1830–3) showed that geological strata could be explained without the need of divine intervention, and Charles Darwin's *Origin of Species* (1859) performed the same service for organic species. Erasmus correctly expounded both subjects, though with too little evidence to convince the world.

Darwin was far more aware than his nineteenth-century successors of the religious and philosophical implications of evolution. For he made the theory a part of his philosophy of maximizing organic happiness: this idea seems to deserve more notice than it receives in the history of philosophy, since it includes and transcends Bentham's concept of utilitarianism, which has had so much influence on English political history.

Darwin's other contributions to science, medicine and technology, which have already been listed earlier in this chapter, are to be found in his massive textbooks and the lengthy Notes to his poems. *Zoonomia* deals with the animal, *Phytologia* with the vegetable and the Notes with the mineral — which includes not only geology, but also sciences such as meteorology and chemistry. His mechanical inventions range from the admired and engineered, such as his speaking-machine, to those which lie unknown as sketches in his Commonplace Book, such as the canal-lift like that later used on the Grand Trunk Canal, the first major English canal — which Darwin helped to promote.

His poem *The Botanic Garden* won him immense contemporary fame, and justly so, for, although he now seems mediocre as a poet, he could compose polished couplets and has never been excelled in describing scientific facts in verse. *The Botanic Garden* remains unique as the only best-selling English poem on a scientific subject.

His other long poem, *The Temple of Nature*, which was better but less popular, is memorable for describing the evolution of life, from microscopic specks to man, in a way which is still largely acceptable and often brilliantly phrased.

Darwin deeply influenced Wordsworth, Coleridge and Shelley, and consequently many of his ideas have been rebroadcast after being finely minced in the minds of three great poets. He also had an untraceable, but probably important, influence on several scientists and technologists of his day, through the meetings of the Lunar Society (which he helped to found).

No one since Darwin has bestridden so easily and effectively the fields of science, poetry and medicine, and now that science has expanded so vastly it is safe to say that no one ever will again.

NOTES TO X: CONCLUSION

1. H. Williams, *Great Biologists*, pp. 87-8.
2. See I. B. Hart, *The World of Leonardo da Vinci* (1961), pp. 207-316.
3. H. Pearson, p. 179.
4. Commonplace Book, p. 51.
5. G. Wichler, *Charles Darwin* (1961), p. 25.

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THE END

VANDYCK STUDIOS

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